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**The Ecology of the Young Stages
of the Atlantic Salmon
in the River Bran, Ross-shire**

By D. H. MILLS, M.Sc., Ph.D.

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of the Atlantic Salmon
in the River Bran, Ross-shire

By D. H. MILLS, M.Sc., Ph.D.

Freshwater Fisheries Laboratory, Pitlochry

EDINBURGH: HER MAJESTY'S STATIONERY OFFICE

1964

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The Ecology of the Young Stages of the Atlantic Salmon in the River Bran, Ross-shire

INTRODUCTION

As part of their plans for the Conon hydro-electric scheme, the North of Scotland Hydro-Electric Board agreed to make available some ten miles of spawning ground in the River Bran, between Loch Achanalt and Achnasheen. This area had formerly been inaccessible to salmon because of falls on the River Conon, a short distance below Loch Luichart. The Board agreed to make these falls passable and this, together with the provision of a Borland fish lift in Luichart dam, opened up the Bran to salmon ascending the River Conon.*

It was known that pike and perch were present in some numbers in the River Bran and the lochs associated with it and arrangements were therefore made to net this system each year from March to October; this netting began in 1952. Further, in order to build up a stock of salmon in the River Bran as quickly as possible, the Hydro-Electric Board agreed to stock this river with unfed fry from their hatchery at Contin. Stocking began in 1953 and has continued each year since. Details of the numbers added are given in Table 6.

Smolts from the planting of unfed fry in 1953 were seen at the upstream face of Luichart dam in 1955, but facilities for their downstream passage were not complete and a trap was not available below the dam to count the downstream migrants. By 1956, facilities for passage downstream were complete and a temporary trap was erected below the dam and this was replaced, in 1957, by a more permanent trap situated slightly farther downstream. The numbers of migrants passing downstream in 1956 and 1957 (1,400 and 350 respectively) were, however, small when compared with the numbers of unfed fry added in the relevant earlier years (Table 6) which indicated that mortality must have been unusually high over the period between stocking and migration. The investigation described in this report was therefore started in 1958 to ascertain the incidence and extent of this mortality.

STRATHBRAN

1. STRUCTURE

The River Bran is the largest of the headwaters of the Conon River system with a catchment area, to the intake to Achanalt power station, of 73.6 square miles (191 km.²) (Fig. 1). A description of the Conon River system has been given by Menzies (1928).

Below Achnasheen the Bran winds for two miles between terraces of lateral moraines formed from its earlier alluvial deposits, upon which the tributary streams on either side are laying down cores of coarser material. Below Dosmuckeran the Bran winds through a wide alluvial plain (Plate 1) which represents the westward foot of the former Loch Bran, which was some four miles in length and the waters of which have been partly silted up by the stream at the head and partly drained at the foot by the lowering of the rock barrier below Loch a'Chuilinn. The former continuity of that loch with Loch Achanalt is revealed by the alluvial terraces which surround both pieces of water.

Loch Achanalt is a shallow, reedy loch in the process of being silted up and is nowhere more than six feet deep. It communicates with Loch a'Chuilinn by a short stream, and the area of these two lochs and the connecting stream amounts to 334 acres (135 ha.). The level of Loch a'Chuilinn has been raised about five feet by the construction of Achanalt Barrage at its downstream end and the loch now has a maximum depth of 45 feet (13.7 m.). A little over a quarter of a mile below Loch a'Chuilinn the Bran, which previously flowed through a rocky gorge of pelitic schist and gneiss into Loch Luichart, has now

* The stream entering Loch Luichart is the River Bran, whereas the stream running out of this loch is the River Conon.

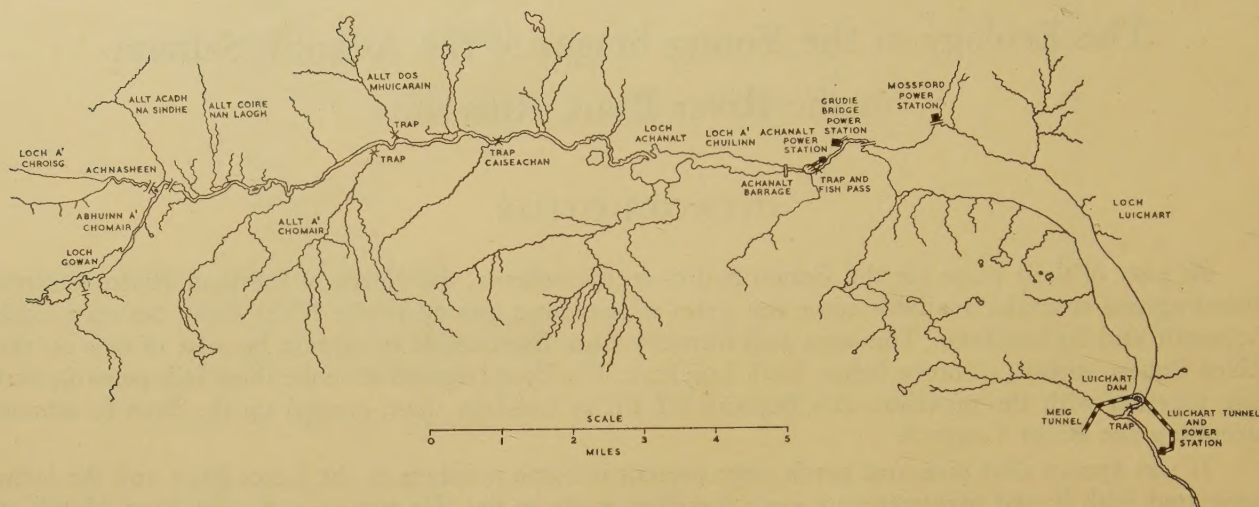


Fig. 1. The Bran watershed

been mostly diverted through a tunnel to Achanalt power station. A small flow, however, passes down a fish pass built into the side of the old river bed in its course through the gorge. The water from the power station is discharged into the river's course approximately 300 yards (274 m.) below its diversion into the tunnel. The Bran flows for a farther quarter of a mile before passing through a smaller gorge into the head of Loch Luichart. Water from Loch Fannich is discharged from Grudie Bridge power station into the Bran 100 yards (91 m.) above this gorge. To the east side of the head of Loch Luichart water from Glascarnoch Reservoir enters *via* Mossford power station.

The waters of Loch Luichart fill a deep and narrow hollow. The floor of this loch forms two rock basins, separated by a rock ridge. The deeper of these basins is situated less than a mile from the head of the loch and has a maximum depth of 214 feet (65 m.), the level of the loch having been raised 50 feet (15 m.) by the construction of Luichart dam. The other basin has its greatest depth, 165 feet (50 m.), half a mile from the dam. The rock ridge barrier crosses the loch near the point where the latter is constricted and over this ridge the maximum depth is only 65 feet (19 m.). The total area of Loch Luichart is some 1,640 acres (664 ha.). Before the construction of Luichart dam the outflow of the loch, known as the River Conon, was over a rock floor a short distance below which were the Falls of Conon. Most of the water from Loch Luichart now passes through a tunnel to Luichart power station but a little passes, as compensation flow,* into the old river bed. Water from the Meig impoundment enters Loch Luichart through a tunnel which opens near Luichart dam.

2. CLIMATE

For most of its length the River Bran lies between 400 and 500 feet (122 and 152 m.) above sea level. The mean monthly air temperature, over the period 1958-61, ranges from 12.1°C (in August) to minus 0.9°C (in January). The extreme records over this period were, maximum 30°C (25th June, 1960) and minimum minus 20.5°C (30th December, 1961). The lowest maximum temperature recorded was minus 15.5°C on 30th December, 1961.

The average annual rainfall for the area (for the standard period 1881-1915) is 77.4 ins. (1966 mm.). The heaviest rainfall normally occurs in October, while the driest months are May, June and September. Fig. 2 depicts the rainfall distribution in Strathbran. The heaviest daily rainfall recorded (3.96 ins., 101 mm.) over the period January 1958 to September 1962, occurred at Druimdhru during the twenty-four hours ending 17th May, 1962.

* A flow of 37 cusecs is maintained during the period 15th March to 11th October and a flow of 9 cusecs over the remainder of the year.

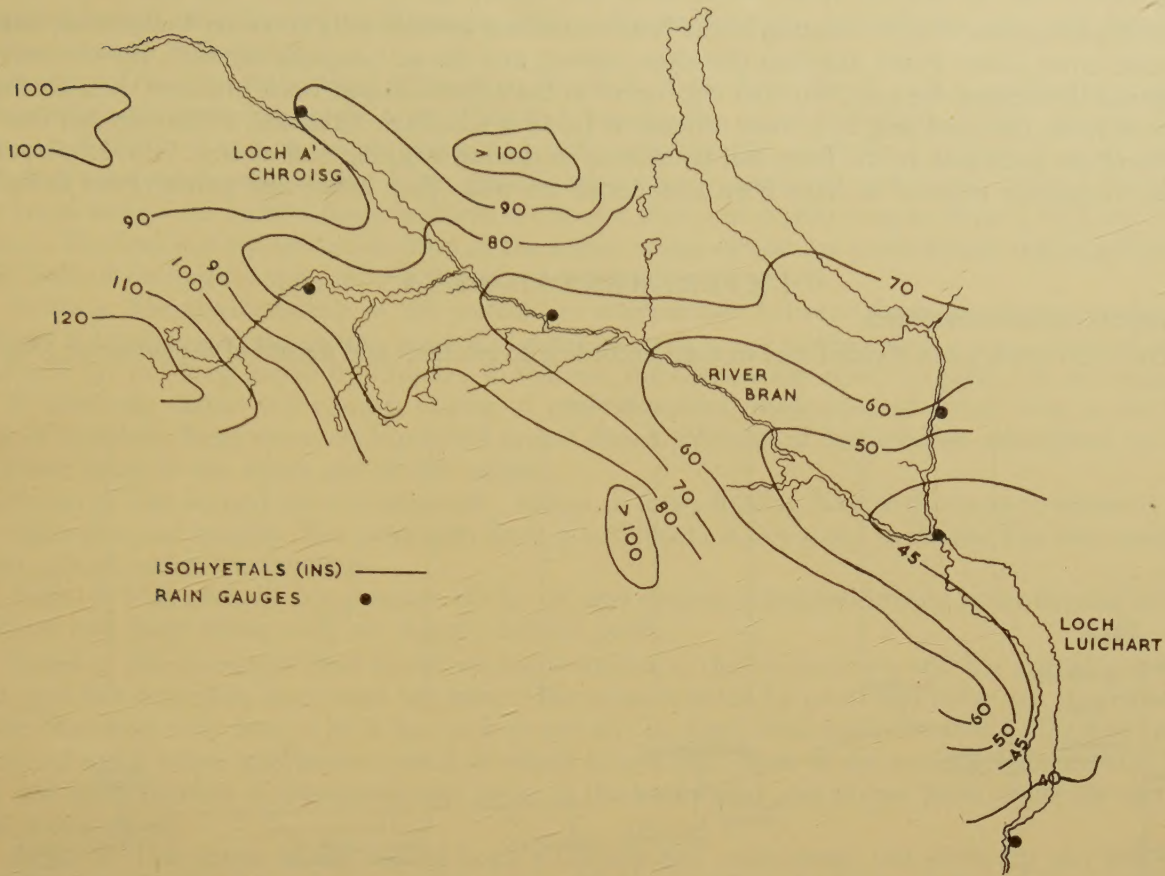


Fig. 2. Rainfall distribution of Strathbran

3. VEGETATION

Most of the area from Loch a'Chroisg and Loch Gowan to Dosmuckeran consists of stretches of deer sedge (*Scirpus (Trichophorum) caespitosus* L.) and heather moor (*Calluna vulgaris* (L.) Drude). These are interspersed with *Molinia-Myrica* swamp and *Sphagnum* bog. This vegetation extends to the river banks which are lined in places with *Juncus effusus* L. and, in the damper areas, *J. acutiflorus* Hoffman. Wild thyme (*Thymus serpyllum* L.) occurs on the stable beds of gravel bordering the river in some places.

At Achnasheen and Dosmuckeran *Molinia* grassland lies on either side of the river and from Caiseachan this grassland stretches on both sides of the river in a narrow belt as far as Achanalt, where there is a certain amount of alluvial pasture. Beyond this belt of grassland is swamp composed of *Juncus* spp. Two large areas of swamp occur just west of Achanalt, one on either side of the river. One of these, on the north bank, marks the site of Loch Bran while the other surrounds Loch Odhar situated on the south side of the river. East of Achanalt more *Juncus* swamp occurs which indicates the original extent of Loch Achanalt. Downstream from Loch Achanalt, to the lower end of Loch Luichart, the area is almost completely heather moor, interspersed with *Molinia-Myrica* swamp.

With this type of vegetation prevailing most of the ground is deer forest and sheep farm although strips of arable land occur at Caiseachan, Achanalt and An Chuilinn.

In the sluggish parts of the river and some of its tributaries there are small patches of water milfoil (*Myriophyllum spicatum* L.), bog pondweed (*Potamogeton polygonifolius*, Pourret), horned pondweed (*Zannichellia palustris* L.). *Myriophyllum alterniflorum* DC, water crowfoot and water moss (*Fontinalis antipyretica* L.) occur in some of the faster reaches of the river.

4. FISH

Of the six species of fish occurring in the Bran watershed possibly only three are indigenous, namely the brown trout (*Salmo trutta*), the char (*Salvelinus alpinus*) and the eel (*Anguilla anguilla*). Brown trout are widespread throughout the area, but char only occur in Loch Fannich and Loch Luichart. Eels are found mainly in Loch Luichart and, to a lesser extent, in Lochs a'Chuilinn, Achanalt, a'Chroisg and Gowan. They have not been seen in the Bran and its tributaries during trapping and electric fishing operations. Two of the species believed to have been introduced are pike (*Esox lucius*) and perch (*Perca fluviatilis*).

EXPERIMENTAL AREA

1. PHYSICAL CHARACTERISTICS

The main stream was divided into sections according to gradient and nature of the substrate (Fig. 3).

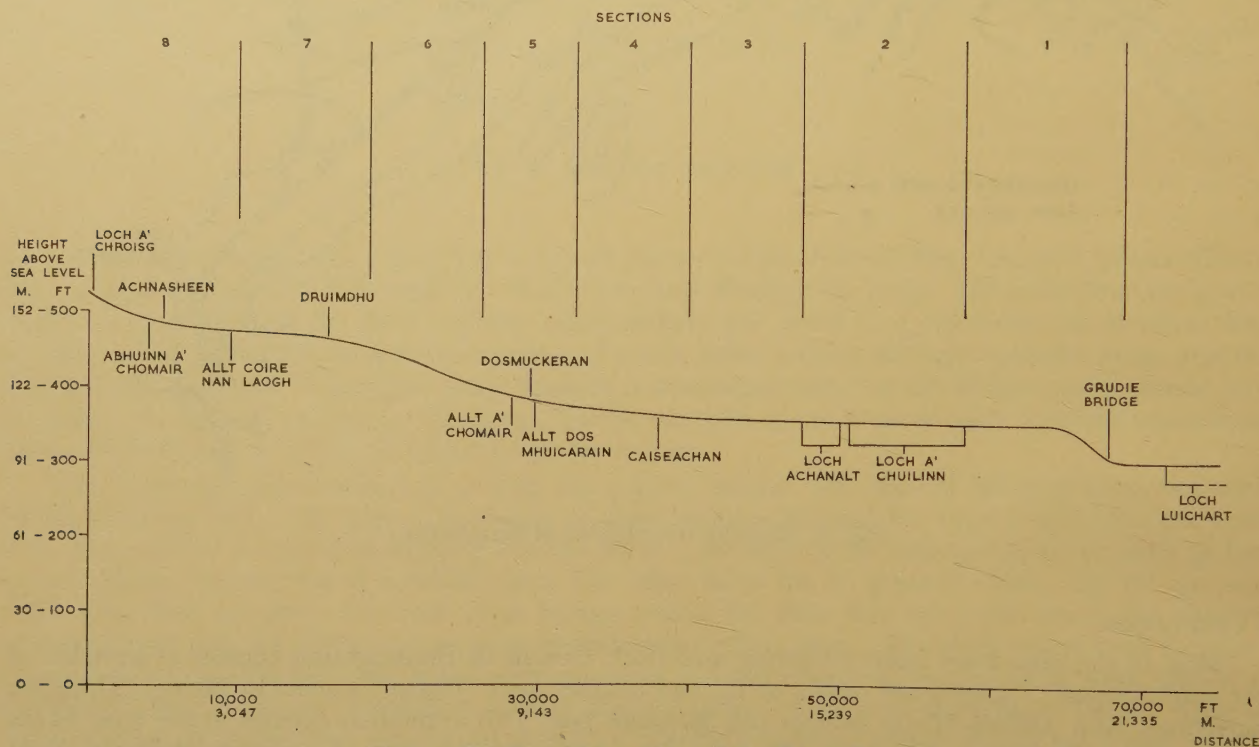


Fig. 3. Profile and zonation of the River Bran

(a) Area

The area of the River Bran and its main tributaries is given in Table 1. The areas of the tributaries shown are those to which young salmon have access and are not necessarily the total area of each stream as, in all the streams except Abhuinn a'Chomair, the upstream movement of young salmon is limited by the presence of steep falls. The gradients given are for the total length of each stream.

(b) Description of Sections

Section 1. This lies between the foot of Loch a'Chuilinn and the head of Loch Luichart. The river here has a gradient of 1 in 131 and flows rapidly over bed rock, boulders and large stones. A number of pools from 3 feet to over 6 feet (2 m.) in depth occur between stretches of broken water. A small amount of cover is available in the form of trees and boulders. Beds of *Zannichellia palustris* occur in the head pond of Achanalt power station.

Section 2. This comprises Loch Achanalt and Loch a'Chuilinn with a 400 yard (366 m.) stretch of broken water joining the two lochs. The gradient is only 1 in 2200. Most of the bed of Loch Achanalt

consists of silt and mud lying over large gravel and small stones while the bed of Loch a'Chuilinn is composed mainly of large and small stones. Beds of *Potamogeton* spp., *Myriophyllum* spp. and *Zannichellia palustris* occur in both lochs.

Section 3. This comprises most of the sluggish reach of the River Bran, with a gradient of 1 in 750, from just below Caiseachan to the head of Loch Achanalt. The upper half of this section consists of pools from 4 to 6 feet (1.3 to 2 m.) deep alternating with short stretches of shallow, turbulent water and the river bed consists of small stones, large gravel and some silt bordered with banks of unstable gravel. The lower half of the section has a uniform width and flow and depths ranging from 5 to 9 feet (1.5 to 2.7 m.). The bed is of silt and mud. Most of the banks in this section are undermined and, together with small beds of *Potamogeton* spp., afford a certain amount of cover to fish.

Section 4. The characteristics of this section are intermediate between those of sections 3 and 5. The gradient is 1 in 500 and the section consists of pools between 2 and 5 feet (0.6 to 1.5 m.) deep and up to 100 yards (91 m.) long joined by stretches of shallow, turbulent water up to 20 yards (18 m.) long. The bed is relatively stable and consists chiefly of well-embedded, medium-sized stones with a few small areas of boulders, large stones and unstable gravel. Small stretches of *Myriophyllum alterniflorum* occur on the stable areas at the lower end of this section.

Section 5. This section has a gradient of 1 in 340, is faster flowing than section 4 and consists of pools and riffles of equal lengths. The pools vary from 3 to 6 feet (1.0 to 2.0 m.) in depth. The bed consists of stones, gravel and a few boulders.

Section 6. This section has a gradient of 1 in 170 and consists of fast and broken water flowing between boulders and large stones with no sharply defined pools.

Section 7. The stretch of river in this section is similar to that in section 5 and has a similar gradient (1 in 350) but meanders more than the latter. The areas covered by pools and riffles are approximately equal; the pools vary from 2 to 6 feet (0.6 to 2.0 m.) in depth but, unlike section 5, the bed consists mainly of small stones and gravel, much of which is unstable. Most of the banks are lined with *Juncus* spp. and small patches of *Potamogeton* spp. occur in the backwaters and deeper pools where silt and mud have accumulated.

Section 8. This starts at the foot of Loch a'Chroisg and ends about 100 yards (91 m.) below the confluence of Allt Coire nan Laogh and the river. With a gradient of 1 in 200, it has a more rapid flow. Pools and riffles occur in approximately equal amounts, but the pools are shallower, 2 to 4 feet (0.6 to 1.3 m.) deep, than those in the previous section. The bed consists of stones, gravel and a very small amount of bedrock. Trees line the banks for a short distance between Loch a'Chroisg and Achnasheen road bridge and *Myriophyllum alterniflorum* occurs on the river bed in this area. A small amount of *Potamogeton* spp. occurs near Achnasheen road bridge.

The characteristics described above indicate differences in the nature of the various sections of the river which may be compared with the zonations proposed by other workers (Carpenter, 1928; Butcher, 1933; Tansley, 1939; Huet, 1946 and Stamp, 1946). Unlike many rivers the Bran does not follow the general sequence of zonations as suggested by Carpenter (*loc. cit.*) where a river starts as a 'highland brook' passes through 'trout beck' and 'minnow reach' zones and ends as a 'coarse fish reach'. Below Loch a'Chroisg the Bran flows through sections 8 and 7 as 'minnow reach' through section 6 as 'trout beck', as 'minnow reach' in sections 5 and 4 after which it becomes 'coarse fish reach' in zones 3 and 2 and reverts to 'trout beck' in zone 1. Macan and Worthington (1951, p. 63) however, point out that rivers do not necessarily have all these zones and a quiet stretch may often be found near the headwaters of a river, or a torrential reach near the mouth.

Most of the tributaries of the Bran, Allt Acadh na Sindhe, Allt Coire nan Laogh and Allt dos Mhuicarain, come into Carpenter's categories of 'highland brook' and 'trout beck'. Abhuinn a'Chomair and Allt a'Chomair show certain characteristics of Carpenter's 'minnow reach' which, while the flow is still fairly swift, have patches of silt and mud in a few places protected from the current where higher plants are able to gain a foothold.

(c) Cover

Cover can be divided into two categories, temporary and permanent. The only temporary cover is that given by weed beds, which are mostly seasonal in occurrence, and moss and algal growth on stones,

though the algae are usually washed off by quite small floods. All three were found to provide some cover for young salmon and trout, affording both protection and habitats for food organisms. Weed beds and moss-covered stones seemed to be more important to fish than algal growth. Some of the stones may be covered by profuse algal growth during periods of low water in the summer. For example, in Abhuinn a'Chomair in July, 1960, 11% of a sample of 100 stones (with an average size of 1570 cm.²) had an algal covering while 48% were moss-covered and at the same time in a sample of 100 stones from the River Bran (Section 8), with an average size of 6155 cm.², 25% were covered with algae and 21.5% with moss. Permanent cover includes trees, bushes, overhanging banks and boulders. Most of the cover available to fish on the Bran system is from overhanging banks some of which are lined with *Juncus* spp. Much of the river bank tends to be undermined by direct flood action and indirectly from denudation of the bank by grazing sheep.

2. FLOW AND FLOODS

The mean annual flow of the River Bran, as far as the intake to Achanalt power station, is 355 cusecs (10 m³/sec.). It was also necessary, however, to determine the frequency of floods because a severe flood might exert considerable influence on the young salmon population through movements of the stream bed, leading to destruction of the bottom fauna and, in the tributary streams, displacement of the salmon fry. Floods during the time of smolt migration might hasten the passage of downstream migrants with beneficial results.

Floods were classified as a) slight (500-1000 cusecs), b) moderate (1000-2000 cusecs) and c) severe (>2000 cusecs). The volume of water flow was estimated in two ways a) the level of Loch a'Chuilinn at Achanalt Barrage, which is continuously recorded at Grudie Bridge power station and b) the water level at Achanalt intake weir. The river level was also noted approximately at each visit and recorded against daily rainfall. It has therefore been possible to obtain a reasonably accurate assessment of the frequency and size of floods during the period April 1958 to September 1962. The results are given in Fig. 4.

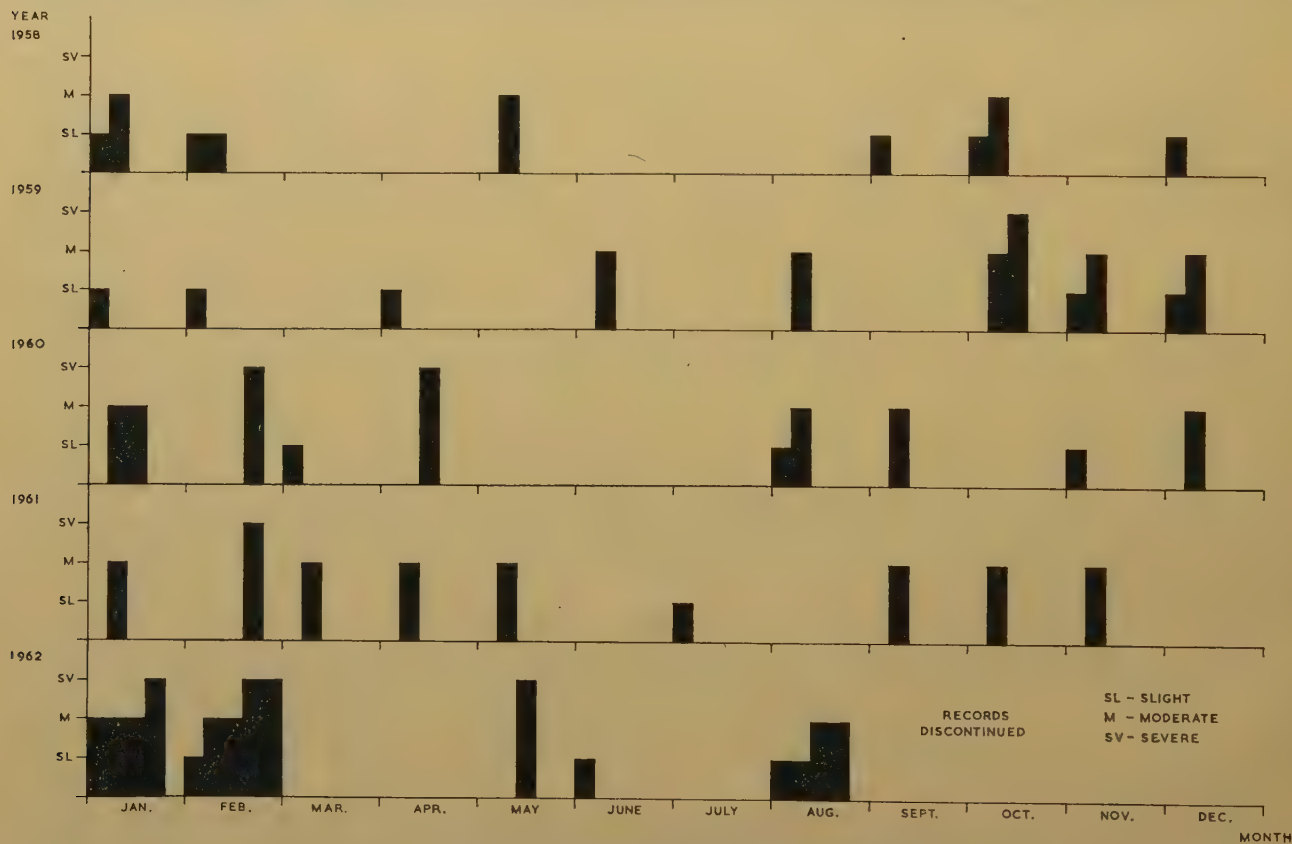


Fig. 4. Seasonal distribution of floods, River Bran

The most severe flood over this period was one with a maximum flow of 4720 cusecs which occurred between 6th and 13th February 1962, and this was followed by a second severe flood, from 15th to 19th February, with a maximum flow of 3670 cusecs. Floods of this magnitude may have a profound effect on the bed of the main river, moving the large banks of unstable gravel which are particular features of sections 3, 5 and 7. The beds of the tributary streams, particularly those with a steep gradient, may be altered considerably and even in a moderate flood large stones are frequently in motion and the effects of such scouring are manifest in the mounds of stones and gravel lying on the banks in the lower reaches of some tributaries, e.g. Allt dos Mhuicarain. In the tributaries with less steep gradients, such as Allt a'Chomair, small stones tend to move in moderate floods but this is not the case in Abhuinn a'Chomair where the stream bed is relatively stable consisting of large, firmly embedded stones.

3. TEMPERATURE

Water temperatures were recorded at each visit at three points in the main stream in sections 4 and 5. Temperatures were generally read at about 11.0 a.m. and, when readings were made at all three points on the same day, they were usually taken within a period of half an hour. The readings at the three points, which were all within a distance of three miles, did not differ markedly and therefore they have been combined when calculating the mean monthly temperatures shown in Table 2. The extreme temperatures recorded ranged from 22.0°C on 23rd June 1960 to almost 0.0°C on a number of occasions in January 1961 and January 1962. The mean temperatures for June and July were well below the upper lethal temperatures for young salmon given by Rushton (1926), Huntsman (1942) and Bishai (1960).

4. CHEMICAL CHARACTERISTICS

Samples of water were taken from various sites on the Bran system between March and May 1962. The results of the analysis of these samples are given in Table 3. It was found that the pH varied from 5.4 to 6.7 while the alkalinity was very low, ranging from 0.4 to 4.6 mg. CaCO_3 /l. These values are to be expected for a moorland river running over the type of terrain already described. The water was relatively poor in other ions, particularly K^+ , Ca^{++} , Mg^{++} and SO_4^{--} .

There was no serious pollution. A very small amount of domestic pollution may occur at Achnasheen and a'Chullin from seepage and at one point immediately below Achanalt power station general domestic refuse from neighbouring houses is tipped into a deep pool, although not in quantities that would have an effect on any fish present.

BOTTOM FAUNA

Samples of the bottom fauna were taken from various sites on the Bran system at different times of the year. They were collected with a shovel-type sampler, which sampled an area of one square foot and which closely resembled the samplers used by Allen (1940) and Macan (1958). The net frame, which has a cutting edge, is 12 inches (30.5 cm.) wide and 18 inches (45.7 cm.) high. Strong minnow netting is attached to the frame to prevent the inner net, made of 60 meshes to the inch grit gauze, being worn and torn by the substrate. Over this net is a metal frame with a large mesh net made of thick twine. This prevents the larger stones falling into the gauze net. One addition to the sampling technique was a sampling frame (the arms of the frame each being one foot long). The purpose of this frame is to outline the sampling area and to prevent gravel and small stones, together with some of the fauna, being pushed ahead of the net.

A list of all animals, excluding the Hydracarina, found in the quantitative samples taken by the shovel net sampler in the River Bran and its tributaries is given in the Appendix.

Samples were taken at fixed sites. From 1958 to 1959 three or four samples were taken each month, except May, from each site and the mean number of organisms per sq./ft. obtained from the average of all sites combined, is shown in Fig. 5. Over this period Ephemeroptera and Chironomidae were the

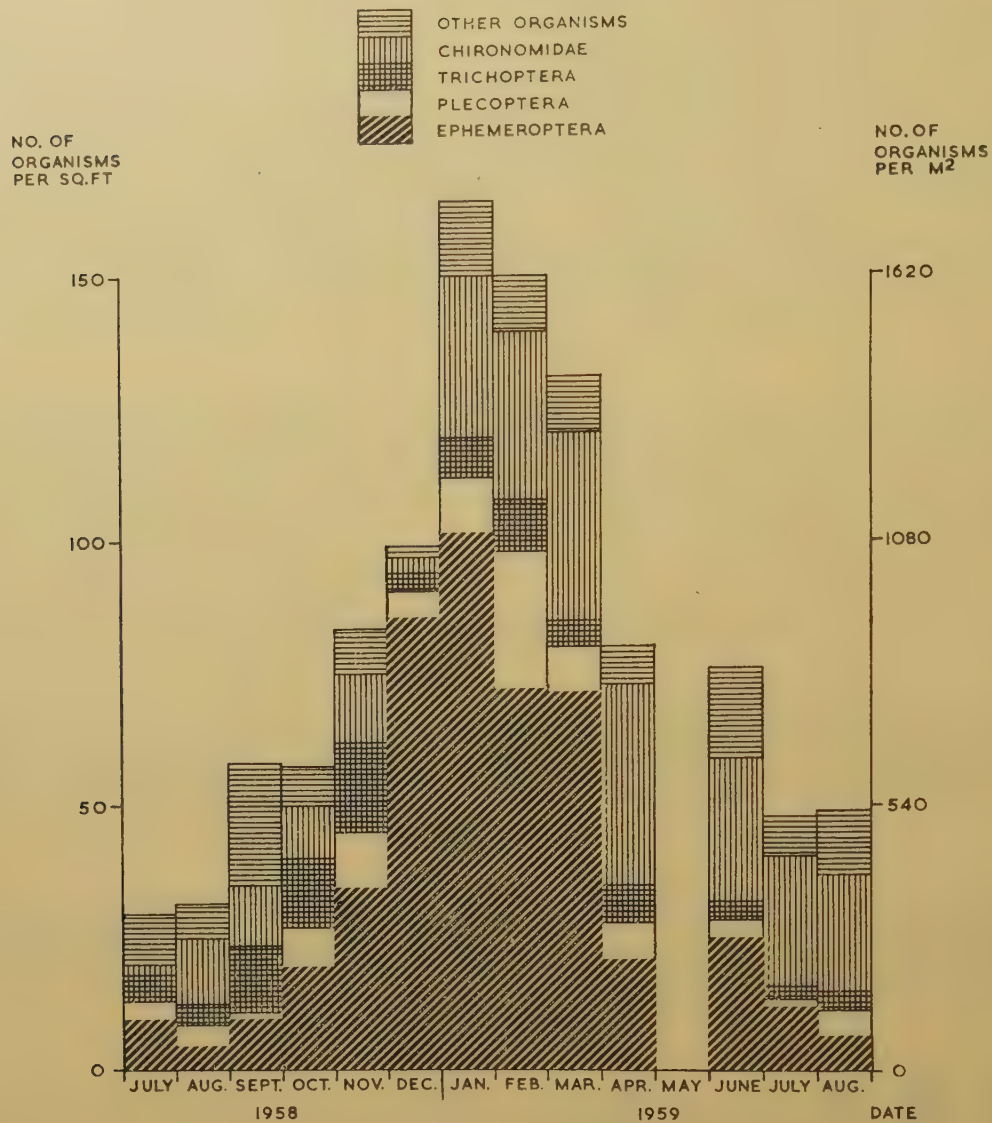


Fig. 5. Average monthly number of bottom fauna organisms in the River Bran, 1958-1959

dominant groups. Maximum numbers of ephemeropteran nymphs, chiefly *Baetis rhodani*, *B. pumilus* and *Ecdyonurus venosus*, occurred from November to March. Chironomid larvae were most abundant from January to April but continued to form an important element in the bottom fauna during June and July. The Plecoptera were the next most important group, being chiefly represented by the nymphs of *Isoperla grammatica*, *Leuctra inermis*, *L. hippopus*, *Chloroperla torrentium* and *Amphinemura sulciatilis*. The largest number of Plecoptera nymphs was recorded in February. Trichoptera were present in slightly smaller numbers than the Plecoptera and showed only slight monthly variations. The most abundant species were *Hydropsyche angustipennis*, *H. instabilis*, *Polycentropus flavomaculatus*, *Stenophylax* spp., *Hydroptila* spp. and *Oxyethira* spp. Other organisms present consisted chiefly of oligochaetes (*Nais* spp. and *Lumbriculus variegatus*), Cladocera (mostly *Eurycercus lamellatus* and *Alonopsis elongata*), Coleoptera (chiefly *Latelmis volkmari* and *Helmis mauei*), other Diptera (mostly simuliids and tipulids), Hydracarina and Mollusca (mainly *Limnaea pereger* and, very occasionally, *Ancylastrum fluviatile*). *Eurycercus lamellatus* and *Alonopsis elongata* were the most abundant of these organisms during August and September while at other times of the year Hydracarina and Simuliidae were the most abundant.

The amount and type of bottom fauna differed in the various sections and the average number of organisms per sample for sections 4 to 8 of the River Bran is given in Table 4. The average density of the standing crop of the bottom fauna population is generally similar in all the parts of the river, except section 6, where more turbulent conditions prevail. However, although the number of organisms is similar, differences in the stream bed are responsible for differences in the composition of the fauna. In section 8, which is situated close to two lochs and where conditions are relatively stable, certain organisms adapted to that environment are also present, for example the leech *Helobdella stagnalis*; the ephemeropterans *Leptophlebia marginata*, *L. vespertina*, *Caenis rivulorum* and *Heptagenia sulphurea* and the molluscs *Limnaea pereger* and *Sphaerium corneum*. In section 4, where stable conditions again prevail, the leeches *Glossisiphonia complanata* and *Helobdella stagnalis* were present together with the cladoceran *Eurycerus lamellatus* and the mollusc *Ancylastrum fluviatile*. Marked differences were also found in the fauna of two of the tributary streams, Allt a'Chomair and Allt dos Mhuicarain, where monthly samples of the bottom fauna from two sites in each stream were taken from October 1960 to March 1961 (Fig. 6).

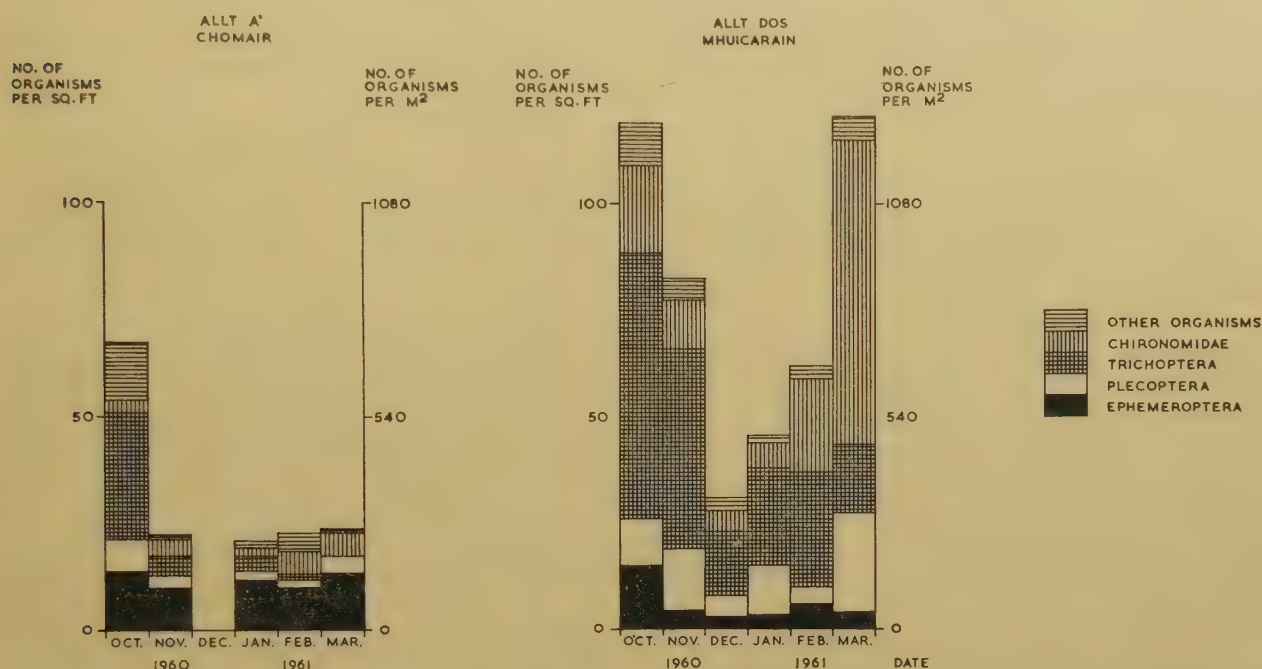


Fig. 6. Average monthly number of bottom fauna organisms in Allt a'Chomair and Allt dos Mhuicarain, 1960-61

In Allt a'Chomair, where the bottom fauna is poorer, Ephemeroptera were the dominant group, chiefly represented by *Baetis rhodani*, *B. pumilus*, *Rhithrogena semicolorata* and *Ecdyonurus venosus*. Trichoptera were the next most important group with *Polycentropus flavomaculatus* and *Hydroptila* spp. as the most abundant species. Plecoptera and Chironomidae occurred in roughly equal numbers. The plecopteran nymphs present in greatest numbers were *Isoperla grammatica* and *Chloroperla torrentium*. Other organisms present included Coleoptera (*Helmis mauei*), Hydracarina and Tipulidae.

The fauna in Allt dos Mhuicarain was much richer with the Trichoptera and Chironomidae as the dominant groups. The Trichoptera consisted chiefly of *Hydroptila* spp. and, to a lesser extent, *Polycentropus flavomaculatus*. As in Allt a'Chomair, they were most abundant during October. The largest numbers of Chironomidae occurred in March. Plecoptera were more abundant than the Ephemeroptera and were represented by *Isoperla grammatica*, *Leuctra hippopus*, *Chloroperla torrentium* and *Amphinemura sulcipectus*, the last species being the most abundant. The Ephemeroptera were interesting in that the most abundant species were *Leptophlebia* spp., *Heptagenia* spp. and *Siphonurus* spp., whereas *Baetis rhodani* and *B. pumilus*,

though present, were not as abundant. The probable reason for the presence of so many 'still-water' species is the proximity of Loch na Moine Beag. Other organisms present were mainly Oligochaeta, Hydracarina and Simuliidae.

Although there are quantitative differences in the fauna from these areas they should be accepted with caution as Mottley, Rayner and Rainwater (1938) cast grave doubt on the significance of the numbers of organisms in quantitative samples, because they found, by taking large numbers of samples, that the distribution of aquatic insects in a stream was not random. Leonard (1939) also showed that variation occurred in the quantitative composition of samples but found that the total volume of organisms present in a given area was more consistent. Badcock (1949 and 1954b) showed that considerable variation occurred between adjacent samples and this was also apparent during the present survey.

Seasonal variations were also considerable and this is apparent in Figs. 5 and 6. This type of variation is well known and recent accounts of it include those by Allen (1941a), Badcock (1949, 1954a and 1954b), Jones (1951) and Hynes (1961).

A comparison of the quantitative assessments made of the bottom fauna of a number of rivers, including the Bran and its tributaries, is given in Table 5. The values given in this table represent the average number of organisms/sample over the whole period which, in most cases, extended over a year. Because of differences in the sampling methods and in the areas sampled, it is not possible to make detailed comparisons but, in general terms, the density of the bottom fauna populations of the Bran and two of its tributaries (Allt Coire nan Laogh and Allt dos Mhuicarain) is comparable with that of other tributaries of the Conon system, one of the tributaries of the Thurso River, the Glenamong River in Ireland and the Welsh rivers Ystwyth, Ceirw and Merddwr, and that of another tributary (Allt a'Chomair) is comparable with the bottom fauna populations of two tributaries of the River Tummel and of the River Tees in England.

Though these comparisons indicate that the bottom fauna population of the Bran system is comparable with that of several other streams, it is also clear that, when the whole range of bottom fauna population density is considered, the Bran and its tributaries cannot be considered to be 'rich' streams; Madden (1935) classified Arizona streams on a numerical basis. If more than 2150 organisms/m², were present, the stream was termed 'rich'; if there were 1080-2150 organism/m², the stream was termed 'average' while any stream with less than 1080 organisms/m² was 'poor'. On this classification the Bran system is poor and, though Madden's views on stream classification have been criticized by Badcock (1954a) the conclusion reached following his method is confirmed by the results obtained by Morgan and Egglshaw (personal communication) in an extensive survey of streams in the Scottish Highlands.

However, Allen (1941a) found that, while the value of the bottom fauna as a source of food corresponds approximately to its density, the correspondence is by no means exact and considerable discrepancies may occur. He noticed that while there was a considerable difference in average population density between the bottom fauna of the Halkirk Burn (280.2/sq. ft. or 3016/m²) and the Sleach Water (377.8/sq. ft. or 4066/m²) on the Thurso system there was no significant difference between them as sources of food for first year salmon. He showed that this arose from the fact that the fauna of the Halkirk Burn was proportionately richer in the more available food animals. Furthermore, as is mentioned later in the present paper, drifting fauna and wind-blown organisms of terrestrial origin are also available and are taken by fish. These are valuable supplements at certain times of the year (Nilsson, 1957) and should be taken into account when any assessment of stream fauna is made. Horton (1961) has shown that in the Walla Brook in Devon there was sufficient food in the drift fauna alone to satisfy the food requirement of the trout.

SALMON

1. FRY AND PARR

Reference has already been made to the stocking operations in the River Bran, which began in 1953 and continued each year until 1961. Details of these stocking operations, which were carried out by the staff of the Conon District Fishery Board, are given in Table 6. The totals shown in this table

include the unfed fry which were added, from 1960 onwards, to some of the tributaries of the Bran in order to make more detailed studies of survival. Further details of these latter plantings are given in Table 13.

(a) *Methods*

The young salmon population was sampled by means of sweep nets and electric fishing apparatus, the latter producing a pulsed direct current of 500 volts. Most of the fish caught were returned to the water, after their length (from the nose to the fork of the tail) had been measured to the nearest mm. and a sample of scales removed, but some were killed and taken to the laboratory where they were weighed and their stomachs preserved in 5% formalin. The food organisms in the stomach were counted individually and identified to species where possible. The total volume of food in the stomachs was measured by volume displacement.

The term *fry* is used for the young salmon throughout its first year of life from the time of yolk sac absorption. For convenience its first year of life is considered to end on 31st March in the year following that in which it was released but the term *fingerling* or *underyearling* is used for fry at the end of their first summer. The term *parr* is used for young salmon from the time they start their second year of life until the onset of *smolt* transformation in their third or fourth year when they become silver and migrate to sea.

(b) *Population density*

A census was made of a number of areas by electric fishing. The downstream end of the area to be sampled was blocked with a small-mesh net (0.4 cm.). A smaller net of similar mesh was used to catch the fish stunned. Each area was repeatedly fished until no more fish were caught. In certain areas, for example Abhuinn a'Chomair and sections 7 and 8 of the River Bran, only small sections between 250 and 1000 sq. yds. (209 and 856 m.²) were fished, but in Allt Coire nan Laogh, Allt a'Chomair and Allt dos Mhuicarain, the whole stream available to salmon was fished latterly. Sections 1 to 6 of the River Bran were not suitable for electric fishing owing to the volume of the water present. No allowances have been made in the results for variations in the efficiency of the electrical fishing apparatus due to differences in conductivity, flow, temperature and substrate. It was found, however, that the apparatus used caught fry as small as 2.9 cm. in length.

Details of the numbers of salmon fry and parr in certain areas of the River Bran and its tributaries are given in Table 7. Over the period August 1958 to March 1959, a census was made of the selected areas to give an estimate of the size of the underyearling, 1+ and 2+ parr population in the river system. The results are expressed as the density index which is the number of fish per 100 sq. yds. or m.². Of the three areas which were planted with fry each year before this investigation two, Abhuinn a'Chomair and section 7, had similar indices of 14.6 (0.17 m.²) and 12.6 (0.15 m.²) respectively. The third area, section 8, which was the upper limit of fry planting and was sampled at the upstream end, had a much smaller density with an index of 4.7 (0.05 m.²). In the three streams, Allt Coire nan Laogh, Allt a'Chomair and Allt dos Mhuicarain, where no fry planting was carried out before this investigation, the indices, while dissimilar, did exhibit an interesting pattern in that the stream farthest downstream, and below the lower limit of fry planting, had a higher index, 14.7 (0.18 m.²) than Allt a'Chomair 7.6 (0.08 m.²) which is half a mile upstream of the former but approximately three miles downstream of Allt Coire nan Laogh which had an index of 7.5 (0.08 m.²).

The density of the salmon population in Allt dos Mhuicarain was the same as that in Abhuinn a'Chomair where fry had been planted. This would suggest that there is a considerable dispersion of fry after planting with the fish tending to distribute themselves over the available river and stream beds. The population of 1+ and 2+ parr (Table 7) seems to be similar in all areas except section 7 (which is low with an index of 4.5 (0.05 m.²)) and Allt dos Mhuicarain (which is high with 14.7 (0.18 m.²)). Elson (1957) has described the dispersion of underyearlings and considered that there was nothing to be gained, when planting underyearlings, by scattering these fish more widely than at a rate of 5,000 per 100 sq. yds. He found that the surviving fish spread fairly uniformly over the stream about half a mile up and one mile downstream and concluded that, to utilize a stream's resources fully, planting sites should not be over two miles apart. This suggests that sections 1 to 4 would be insufficiently stocked as

the lower limit of fry planting was approximately half a mile upstream from the confluence of Allt a'Chomair and the main river. This also appears to apply to Allt Coire nan Laogh, Allt a'Chomair and Allt dos Mhuicarain as, after fry planting in these streams, the indices rose to 20.2 (0.24 m²), 17.2 (0.20 m²) and 21.8 (0.26 m²) respectively. However, it is interesting to note that while the overall index rose in every case, the index for 1+ and 2+ year old parr only rose in Allt Coire nan Laogh (from 7.5 to 14.7 (0.05-0.18 m²)) while it remained the same in Allt dos Mhuicarain and dropped slightly in Allt a'Chomair. In these latter burns all the available territory was probably being utilized.

Two other tributaries of the River Conon, the River Blackwater and the River Meig, were each sampled once in May and were found to have comparable parr indices of 7.6 (0.08 m²) and 8.6 (0.010 m²) respectively. The area on the Meig was one where salmon are known to spawn and that on the Blackwater, where no salmon spawn, was an area where fry planting is carried out each year.

The population densities of parr in the Bran and its tributaries are also similar to those in the Pollett River, New Brunswick, Canada, between 1948 and 1951 where minimum values (assuming that all the fish in seven selected sample areas were caught) ranging from 5.0 to 11.4/100 square yards (0.05 to 0.13 m²) were found and maximum values (assuming that the total catch represented 79% of the fish available) of 6.3 to 14.4 (0.07 to 0.17 m²) (Elson, 1962). The corresponding value for the Bran system was estimated, on the basis of the census made from August 1958 to March 1959, as 7.3 parr/100 sq. yds. (0.08 m²). No allowance has been made for the population densities in sections 1 to 4 but this value is considered to be representative of the area as a whole as observations from netting in section 4 suggests that the density in this area at any rate is similar to that in section 8. Owing to the depth and width of sections 2 (which includes Loch Achanalt and Loch a'Chuilinn) and 3 no assessment could be made for these areas. Using this value, it is estimated that the total parr population of the Bran and its tributaries (excluding Lochs Achanalt, a'Chuilinn and Luichart), was about 37,000 in 1958-59. As these 1+ and 2+ parr have resulted from a planting of 1,435,000 unfed fry, this indicates a survival of 2.5% from the unfed fry to the parr stage.

(c) *Growth*

Details of the growth of salmon fry in the River Bran and its tributaries, in the years 1958 and 1959 combined, are given in Table 8 and of the growth of fry in Allt dos Mhuicarain and Allt a'Chomair are given in Table 9.

In both tables it can be seen that, during the first year, the biggest length increment is added during August and Table 9 shows that growth in Allt dos Mhuicarain and Allt a'Chomair continued until November or December. Allen (1940) has shown that salmon in their first year in the River Eden have an early period of rapid growth, lasting until mid-August, and a later period of slow growth.

Measurements of a sample of 100 fry reared at the North of Scotland Hydro-Electric Board's salmon hatchery at Invergarry, made in September 1958, indicated a mean length of 4.8 cm. (standard error $\pm$ 0.072 cm.), which suggests that there is little difference in the mean lengths of the fry from the Bran and fry reared at Invergarry.

The results of the readings from 628 sets of scales taken from parr caught in the Bran system are given in Table 10, which shows that there is little difference in the growth rate of parr from the various areas and tributaries of the Bran. The growth of parr on the Bran is similar to that of parr from the Forss, Caithness (Frost, 1950) and the Sinclair Burn, a tributary of the Thurso River, Caithness (Allen, 1941b).

The condition factor of salmon parr of both sexes generally increased from February to May. For female parr there was a general decrease in this factor through the summer and autumn but male parr had their highest condition factor in September. Presumably this occurred because some of these males were maturing. A direct comparison of the values obtained for parr in the Bran system with those quoted by Allen (1941b) for the Thurso system shows the latter to be substantially higher. When Allen's values are corrected, however, in the way he suggests to allow for the fact that his values were calculated from preserved fish, the corrected values for the Thurso system are slightly lower than those for the Bran system.

(d) *Food*

The stomach contents of 353 salmon fry and 297 salmon parr were examined and the results are given in Tables 11 and 12. Fish were taken from various sections in the main river and from a number of the tributaries, Abhuinn a'Chomair, Allt Acadh na Sindhe, Allt Coire nan Laogh, Allt a'Chomair and Allt dos Mhuicarain. The data from all these areas have been combined.

(i) *Salmon fry*

From January to March, in June and in November nymphs of Ephemeroptera and Plecoptera were the chief organisms in the diet of the fry, particularly *Baetis* spp. Chironomid larvae formed a large part of the diet throughout the year, particularly from June to October. Two trichopteran genera, *Hydroptila* spp. and *Oxyethira* spp., were very common in the diet of fish from August to October and other workers (Allen, 1941a and Piggins, 1962) have mentioned the abundance of these organisms in the diet of young salmon. *Hydroptila* spp. were the most abundant organisms in the bottom fauna from October to February in Allt dos Mhuicarain and in October in Allt a'Chomair (Fig. 5). Allen (*loc. cit.*) has suggested that young salmon chiefly select a few of the most common food animals and *Baetis* nymphs and chironomid larvae were among the animals he found to be selected most frequently.

Cladocera, mainly *Alonopsis elongata* and *Eurycerus lamellatus*, were very common in the stomach contents of fry in July, August and, particularly, September, and as many as 110 organisms have been found in the stomach of one fish. Both these cladocerans were found to occur in bottom fauna samples in approximately equal numbers and they may have been taken from the bottom by the fish, but *Alonopsis elongata*, which also occurs in the drift fauna of the Bran and its tributaries (Shackley, personal communication) may have been taken in mid-water.

The fry were found to have taken very little surface food, such as winged Ephemeroptera, Plecoptera, Trichoptera, adult Diptera or terrestrial organisms.

(ii) *Salmon parr*

During the winter months Ephemeroptera and Plecoptera nymphs were the chief food of the parr, but chironomid larvae were taken frequently throughout the year. The larvae of *Hydroptila* spp. were taken very frequently and from July to November these were the most abundant organisms in the stomach contents. Very little surface food was taken, though winged Ephemeroptera, Plecoptera and Trichoptera were taken occasionally. Adult Diptera were taken more frequently but, from the state of development of their wings, it is probable that they were taken below the surface immediately prior to hatching. Terrestrial organisms, such as froghoppers, beetles and spiders, were taken infrequently.

Salmon fry were found in salmon parr stomachs in April and July. Those taken by parr in April had only been planted in the stream a few days before, and six of a sample of 10 parr, with an average length of 8.5 cm., taken from Allt Coire nan Laogh in April 1961, had an average of four salmon fry in their stomachs. A number of the parr caught in the traps in Allt dos Mhuicarain and Allt a'Chomair also contained fry at this time. The smallest parr found to have eaten fry was 6.3 cm. long.

(e) *Fry survival*

In order to study the survival of fry in greater detail it was decided to plant fry in some of the tributary streams. The streams chosen for this study were Allt a'Chomair, Allt dos Mhuicarain and, later, Allt Coire nan Laogh (Fig. 1). Allt a'Chomair is about 6160 yards (5630 m.) long and has an average annual flow of 24 cusecs ($0.7 \text{ m}^3/\text{sec.}$). Allt dos Mhuicarain is about 2640 yards (2415 m.) long and has an average annual flow of 7 cusecs ($0.2 \text{ m}^3/\text{sec.}$). Allt Coire nan Laogh is about 2640 yards (2415 m.) long and has an average annual flow of 9 cusecs ($0.2 \text{ m}^3/\text{sec.}$). In their upper reaches the three streams flow through areas of deer grass and heather moor, *Molinia-Myrica* swamp, *Sphagnum* bog and, lower down, through *Molinia* grassland with *Juncus effusus* along the banks.

Wolf-type traps (Plate 3), in which the horizontal framework was covered with 1/10 in. (2.5 mm.) wire mesh, were built near the mouths of Allt dos Mhuicarain and Allt a'Chomair. These enabled records to be made of downstream movements. These traps were fished continuously except for periods when they were covered by snow, ice or floods. A census was made, at certain periods each year,

of the fish population present in each stream, using electrical methods of fishing. All fish were measured and marked by fin-clipping, the combination of fin-clips differing for each stream. Although regeneration of the fin occurred the marked fish could be recognized at the census in the following years due to the characteristic deformity of the fin after regeneration.

The fry were added to Allt dos Mhuicarain over an area of 1270 square yards (1060 m^2) bounded downstream by the trap and upstream by falls which are impassable to fish. In Allt a'Chomair the fry were placed in a section of 4915 square yards (4100 m^2) in area. Downstream, this area was again bounded by the trap but the upstream boundary was a small fall which can be negotiated by fish after their first year, so that the area available to older fish is 8560 square yards (7150 m^2). The area available to fry in Allt Coire nan Laogh is 3630 square yards (3032 m^2). The section in which fry were planted in Allt dos Mhuicarain has a bed of flat stones with a few emergent rocks, many with permanent moss covering and, during the summer, some algae. The beds of Allt a'Chomair and Allt Coire nan Laogh consist of coarse gravel, loose angular stones, emergent rocks and, upstream, exposed bed rock. There is no moss on the stones and only a scanty algal covering during the summer.

The fry were transported from the hatchery by lorry in tanks supplied with air. The transport period was approximately 30 minutes. The number of fry planted in these streams is given in Table 13.

Details of the numbers of fry, parr and smolts moving downstream are given in Tables 14 and 15, which show that most of the fry taken in the traps were caught within the first five weeks after planting. This may be due to dispersal or emigration because of high population density (Kalleberg, 1958) or food shortage (Wynne-Edwards, 1962, p. 139). These tables also show that there is a downstream movement of parr in the spring and again in the autumn. The spring movement consists mainly of 1+ year-old parr while that in the autumn consists mainly of 1+ and 2+ mature male parr.

Over the period in which the majority of the fry passed downstream daily numbers entering the traps were compared with the rainfall figures for the previous 24 hours. The results (Table 16) show that the numbers of fry entering the traps increase with a rise in water level and a consequent increase in flow. In Allt a'Chomair the downstream movement was also shown to be related to an increase in stocking density (Table 17); this will be discussed later (p. 19).

During September 1960, Allt dos Mhuicarain and Allt a'Chomair were fished electrically and it was found that then only just over 1% of the fry planted some four months earlier were present (Table 18). During September 1961, all three streams were fished electrically and it was found that only 0.2% of the fry planted in Allt dos Mhuicarain were present, while in Allt a'Chomair about 1% remained in the stream and in Allt Coire nan Laogh 1.3%. Allowing for the fry which migrated out of these streams, the subsequent fate of which is not known, the mortality in Allt dos Mhuicarain in 1960 was 98.4% and that in Allt a'Chomair 98.1%. Some fry may have been washed out of these streams during two small floods, each lasting about a day, in June 1960, but it is thought that losses from this cause are not significant because (a) the post-planting movement was evidently over before the floods occurred and (b) electrical fishing in Allt dos Mhuicarain, carried out on 21st June 1961, showed that the proportion of fry remaining was then of the order of 1.0% and there had been only one day's flooding, in late May, in the interval since stocking. The percentage which died in Allt dos Mhuicarain and Allt a'Chomair in 1961 was the same, 99.6.

The size composition of the fry and parr in these tributaries is given in Figs. 7 and 8. It will be seen that the 0 group and a portion of the 1 group are fairly distinct.

Some of the reasons for the downstream movement of fry are suggested by the observations made by Kalleberg (1958) in a stream tank. He found that salmon fry tend to disperse when they begin to feed, that feeding was common among the fry three to four days after emergence from the gravel and that during the first two weeks the feeding behaviour exhibited an increasing specialization by being directed towards open water. Le Cren (Freshwater Biological Association, Twenty-ninth Annual Report, pp. 33-4 (1961)) found that experimental populations of brown trout fry also tended to disperse in the limited area available to them and considered that dispersal was probably more important under completely natural conditions. Wynne-Edwards (1962) discusses the effect of shortage of food on a population and states (p. 139) that 'instead of this resulting in a general and uniform debilitation of all

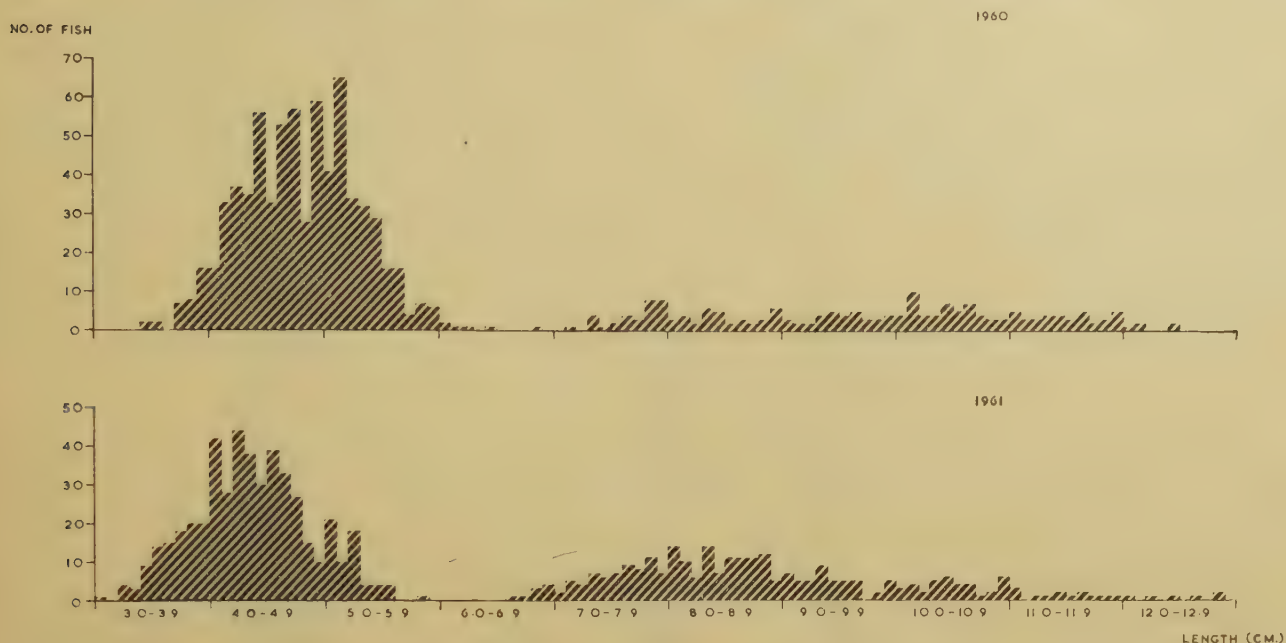


Fig. 7. Size composition of young salmon in Allt a Chomair

the members of the society alike, and perhaps their ultimate extinction, the dominant animals are given a preferred chance of sustaining life and vigour throughout the period of famine'. This dominance behaviour, he says 'ensures that only as many as the remaining sources can sustain are allowed to partake of the food . . . ; the excluded subordinates either perish quickly or emigrate to search for subsistence elsewhere'.

It would appear that the stocking densities in these three streams were high and some indication of the effects of increasing the density of a fry population was obtained in Allt a'Chomair in 1960. That year, three batches of fry were planted in this stream at weekly intervals. The numbers subsequently migrating downstream are given in Table 18, which shows a sharp increase in the proportion migrating downstream as the fry population increased.

Kalleberg (1958) found that, at moderate population density and normal current velocity, all juvenile salmon in an aquarium occupied territories and suggested that the reason why territories were finally abandoned might be increasing competition within the population because the individual had outgrown its environment or changes of water current. He suggested that the velocity of current influences young salmon by (a) forcing the fish to leave exposed stations, and so acting directly on territoriality and (b) by affecting the special adjustment of juvenile salmon and trout to drifting prey. He also found that, in an aquarium, if the fry density exceeds a critical limit the population splits into two fractions, one occupying territories and the other, with no territories, being markedly unstable. This suggests a critical density for stocking fry and is supported by Le Cren's results (1961).

The heavy mortalities which occurred in the two streams may well have been due to the high rate of stocking, because Le Cren (*loc. cit.*) found that mortality in his brown trout populations could be as high as 97% if the stocking rate was very high. Horton (1961) also found a mortality of between 92% and 96% between the alevin and yearling stages of brown trout under natural conditions. In Le Cren's stream the optimum density was seven fry per square yard. Le Cren also found that deaths probably mainly occurred between 20 and 40 days after the fish began to feed. The records for Allt dos Mhuicarain in 1961 indicate that less than 1% of the fry added remained in the stream some 60 days after stocking, so the period of heavy mortality in young salmon may well be similar to that for young trout.

While stocking densities are, without doubt, an important factor governing the survival of fry other factors are also important. For example, the population density of the older fish already present



Fig. 8. Size composition of young salmon in Allt dos Mhuicarain and Allt Coire nan Laogh

in the stream will be a factor affecting the survival of fry and it is shown that trout (p. 28), salmon parr (p. 17) and salmon smolts (p. 27) take salmon fry. Further, there will be competition for the available territory and food. Fig. 7 shows that in Allt a'Chomair, where no fry were planted in 1959, the older age groups were poorly represented in September 1960 and the survival of fry in this stream was 1.4% of the total planted. In 1961, when more one-year-old fish were present, the survival of the current year's fry was only 0.9% of the total planted. The results of the census in Allt Coire nan Laogh in September, 1961, give corroborating evidence and reveal that there was a relatively better survival (2.6%) of the 15,000 fry planted in 1960 than there was of the 16,900 planted in 1961 which had a survival rate of only 1.3%. During the latter year, one-year-old fish were well represented while the proportion of two-year-old fish is small (and similar to that in the other streams) because many will have migrated as 2+ year smolts. Burnet (1959) found that the survival of young brown trout in the streams running into Lake Ellesmere, New Zealand, was seriously affected by the numbers of older fish present and concluded that fry should only be added at intervals of three or four years.

The size composition of the fish in Allt dos Mhuicarain does not follow the same pattern as in Allt a'Chomair and Allt Coire nan Laogh. In 1960, the one-year-old parr were well represented after a stocking of 28,000 fry in 1959, but in 1961 the survival of the fry was only 0.2% of the total planted and the older age groups were also less numerous. This is probably due to a number of factors, including the occurrence of drought conditions in May, resulting in less territory and food being available to the fry at a critical time and the removal of fry at this time for feeding studies. The smaller number of parr is due to the fact that 109 parr and smolts passed downstream between October, 1960 and September, 1961. In this connection it should be mentioned that the trap at the mouth of the stream prevents upstream movements which might repopulate the stream. That upstream movement does occur is shown by the presence of parr in these streams before fry planting began.

The average sizes of the fry and 1+ parr in Allt Coire nan Laogh were smaller than those for the other two streams which suggests that here food was probably a factor limiting growth. The average size of fry in the other two streams was higher but the survival was poorer suggesting that other factors such as availability of territory are important limiting factors. If there were more but smaller territories in Allt Coire nan Laogh, due to the physical nature of the stream bed, the fish would have less room to search for food. Kalleberg has shown that in streams with large stones there are more but smaller territories available for fish owing to fish being out of sight of each other, while in streams with only a few stones on a substratum of gravel, territories were necessarily large due to the antagonistic behaviour of neighbouring fish. This suggestion is further corroborated by Gilson's statement (1961), referring to young trout that there 'was evidence from the study of stream populations and their behaviour . . . that the capacity of a river to produce trout depends not only on the food supply, but often to a greater extent on the number of nooks and crannies where fish can lie'.

2. SMOLTS

From 1960 to 1962 the smolt population migrating from the Bran system was sampled in order to estimate its size and age composition and to mark an adequate sample of the migrants in order to trace their subsequent passage downstream.

(a) *Methods*

The traps used were box traps each consisting of a wooden frame approximately five feet square and four feet high with a V-entrance with an inclined ramp. The latter served to lead the fish into the funnel entrance and, on entering the trap, they could drop to the bottom of the trap a foot below the opening. The framework was covered with $\frac{1}{2}$ in. mesh cotton netting.

On 23rd March, 1960, one of these box traps was placed at the Wooden Bridge crossing the Bran at Caiseachan, about two miles below Dosmuckeran, and on 26th April, a second trap together with an inch-mesh wire netting leader was added, running from one trap to the left bank. A second leader from the other trap to the right bank was erected on 3rd May. In 1961 and 1962 the same trap site was used, with four box traps complete with leaders to each bank (Plate 2).

Another trap was placed in the Achanalt fish pass. In 1960 perch traps (Worthington, 1949) were used, but in 1961 and 1962 a box trap was installed in one of the fish pass pools (Plate 4).

In 1961 two box traps were placed in position below the Borland fish lift at Luichart dam to determine the number of smolts using this exit compared with the number using the smolt chutes running down either side of Luichart dam (Pyefinch and Mills, 1963). No trapping was carried out at this site in 1962.

The final checkpoint on the system is the Wolf trap about a quarter of a mile downstream from Luichart dam.

(b) *Migration*

(i) *Smolt migration—1960*

Tables 19 and 20 give details of the numbers of fish entering the traps at the Wooden Bridge at Caiseachan and Achanalt fish pass during the smolt migration.

The parr and smolts released at each trapping point received a combination of fin-clips for their identification.

The number of fish entering the trap daily was compared with the rainfall and water temperature. After 3rd May (when the whole width of the river was covered) the number of smolts entering the trap appeared to be related partly to the rainfall (e.g. on 3rd, 4th and 11th May) and partly to rising water temperature, the major part of the run entering after the water was fairly consistently above 10°C. White and Huntsman (1938), White (1940), Wolf (1950), Hayes (1953) and Elson (1962) all showed that the major part of the smolt run occurred after the water temperature had risen above 10°C fairly consistently (see Figs. 9 and 11).

The number of recaptures of fin-clipped fish at points downstream from their site of release were, this season, extremely small and, of the 996 fish fin-clipped at Caiseachan and Achanalt fish pass, only 8 were recaptured below Luichart dam. However, it is known that a proportion of the smolts did not pass out of Loch Luichart as small shoals were seen at the dam face in late June and early July and one smolt of 22.8 cm. was caught in the loch three miles upstream of the dam on 18th July.

(ii) *Smolt migration—1961*

In 1961, the 'smolt' migration at Caiseachan occurred over the period 12th April to 8th May and during this period 2,907 silver parr and smolts entered the trap. Fig. 9 shows the numbers entering the trap each day and again suggests that the numbers entering are related to temperature.

The 'smolts' were subdivided into (a) those in which smoltification was only beginning and in which the parr marks were still discernible and the caudal and pectoral fins were still yellow and (b) those which had completely smoltified and in which the parr marks were obliterated and the caudal and pectoral fins were almost completely black. This classification was somewhat arbitrary but it was satisfactory enough to indicate differences in the degree of smoltification during the migration period. On this basis 38% of the migrants were smolts.

Of the 2,907 silver parr and smolts entering the box traps at Caiseachan 324 were tagged before release, 2,550 were released after removal of the adipose fin and 18 (which had been marked previously in the burn) were already marked.

Details of the trap records from Achanalt fish pass are given in Table 21 and Fig. 10. The total recorded is substantially less than that at Caiseachan but it should be remembered that, at Achanalt, migrants can pass through the power station when the latter is on load, so that records from the trap in the fish pass are presumably only part of the total migrating. When the station was on load, smolts were seen to pass through the trash screens at the intake but, as is shown in Fig. 10, there is no clear relation between periods of generation at Achanalt power station and the number of smolts entering the trap in the fish pass.

Of the 1,026 unmarked silver parr and smolts entering the trap, 138 were released tagged and 827 after marking by the removal of the adipose fin.

Of the 3,851 smolts released after marking at various sites on the Bran, 428 (11.1%) were recaptured at the three trapping sites immediately below Luichart dam and at Luichart trap. The details of the

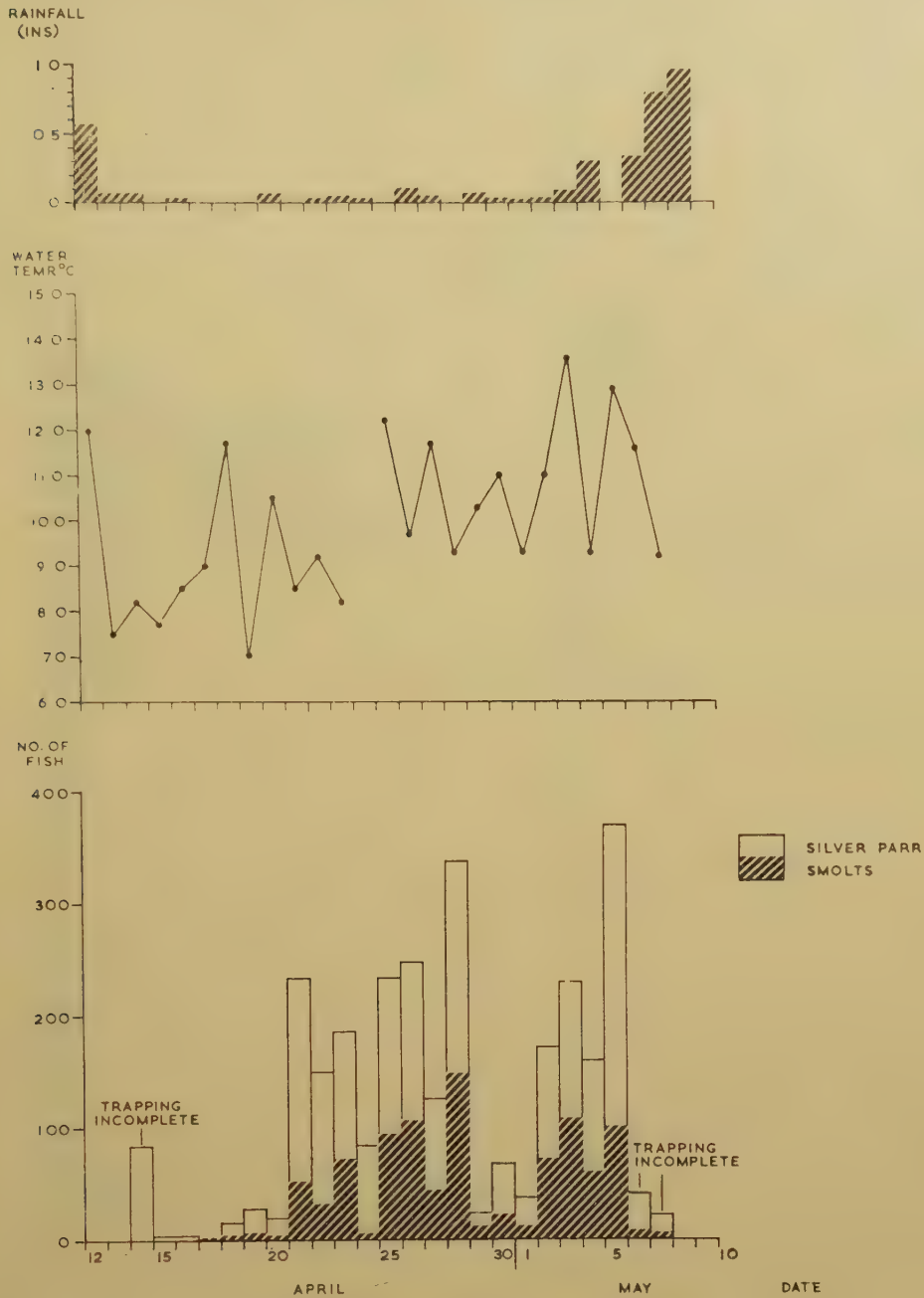


Fig. 9. Smolt migration, Caiseachan, 1961

catches in the traps immediately below the dam, are summarized in Tables 22 and 23. It is interesting to note the similarity in the overall percentage of marked fish in the total number caught at each site.

From the recapture of tagged smolts released at certain sites it has been possible to assess the speed of migration between the various points. This information is summarized in Table 24. The results given in this table suggest that fish released at Achanalt fish pass moved downstream rather slower than any of those released at Caiseachan. This difference would, however, seem to be fortuitous. A more detailed analysis of the records shows that movement downstream is more rapid after a rise in water level and the lower average speed of the releases at Achanalt fish pass is due to the fact that this batch of fish contained a higher proportion of releases when water levels were low.

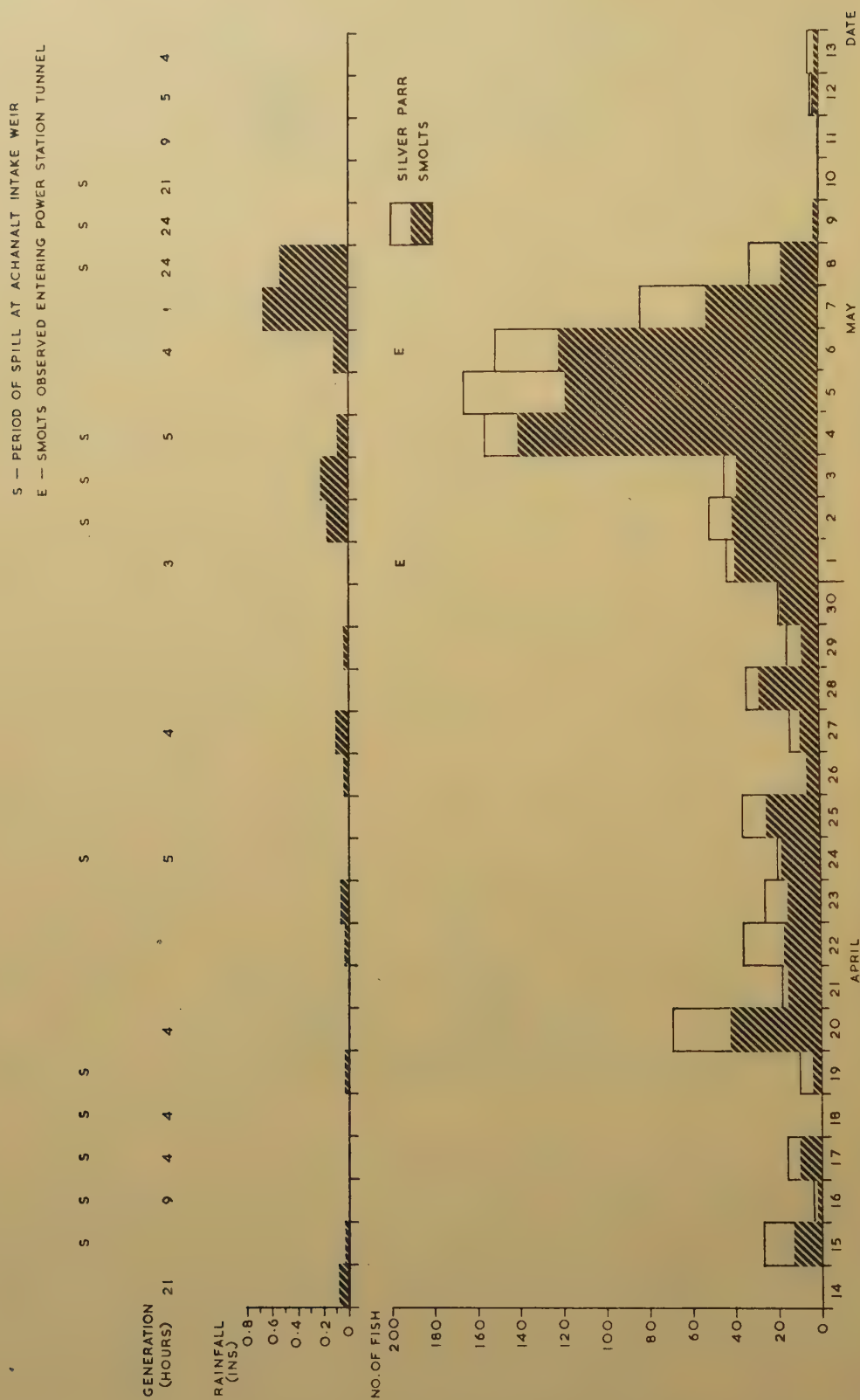


Fig. 10. Smolt migration, Achanalt fish pass, 1961

As in 1960, although few smolts were caught below Luichart Dam after the middle of June smolt shoals of varying size were seen at the dam face up to the middle of July. An echo-sounding survey carried out in late June and July, revealed only small shoals of fish which could have been smolts, char or perch.

(iii) *Smolt migration—1962*

During the period 16th April to 15th May, 3,767 silver parr and smolts (of which approximately 53% were smolts) were caught in the box traps at Caiseachan. A total of 808 fish were released tagged from this site (including 34 fish already tagged upstream at Allt a'Chomair or Allt dos Mhuicarain) and the remainder, with the exception of 10 dead, were marked by the removal of the adipose fin. Any fish which entered the traps bearing a fin-clip denoting their origin in either Allt a'Chomair or Allt dos Mhuicarain were tagged.

Fig. 11 shows the daily smolt migration at Caiseachan. As in Fig. 9, it can be seen that the main part of the smolt run occurred after the water temperature had risen above 10°C. The smolt migration in 1962 was later than in 1961 and one reason for this may be the exceptionally severe winter with low water temperatures lasting well into March. Fig. 11 does not give a complete picture of the migration at this trapping site in 1962 as 983 silver parr and smolts were netted immediately upstream of the traps during the first two weeks of May and released below them. This was because, under prevailing low water conditions, it was considered, from observations on the behaviour of shoals of smolts at the entrance to the trap, that the traps were hindering downstream migration.

From 9th April to 16th May 662 silver parr and smolts (of which approximately 91% were smolts) were taken in the Achanalt fish pass trap. This total is considerably less than that for 1961 and the difference may have been due to more frequent generation at Achanalt power station. In view of the lack of a clear relationship between the period of generation at Achanalt power station and the catches in the Achanalt fish pass trap (p. 22), however, this is uncertain. All fish taken at the Achanalt fish pass trap, other than those already tagged upstream and with the exception of eight dead, were released after the removal of the adipose and distal portion of the right pelvic fin. Those fish which had been previously fin-clipped at Caiseachan were marked by removal of the distal portion of the right pelvic fin. Out of 4,764 fish marked and released at various points upstream 112 (2.3%) entered the Achanalt trap; these constituted 16.9% of the total number caught at this point. The main part of the run occurred when rain had fallen over the period 7th to 10th May.

A fyke net was set about 50 yards below Achanalt intake weir outside the fish pass in an attempt to catch any smolts using this route downstream during periods of light spill which occurred practically every morning at the start of generation during the 1962 smolt season. One trout and 19 smolts (16 of which had been marked at Caiseachan) were caught. Six of the smolts least damaged by the net were tagged and one was recaptured subsequently in the Luichart trap. Small shoals of smolts were also seen in the larger pools downstream of the intake weir and individual fish were found immediately below the weir in isolated pools which are left when the spill over the weir stops.

Of the 5,312 smolts released after marking at various sites on the Bran system 340 (6.4%) were recaptured in the Luichart trap.

Details of the speed of migration between various points are given in Table 25.

The most rapid rate of migration was in the faster reaches of the river between Allt a'Chomair and Allt dos Mhuicarain and Caiseachan. During their passage through the more sluggish parts of the river below Caiseachan and through the lochs the rate of movement of the migrants was generally slower. The speed of migration this season was slightly higher than that shown by marked smolts in 1961. Allen (1944) gave the observed rates of travel of smolts on the Thurso system as from 0.06 to 3.7 miles per day (0.14 to 5.94 km. per day) and in their newsletter for August 1961, the Atlantic Sea Run Salmon Commission mentioned that some smolts took as long as 14 days to negotiate the 2.5 miles (0.18 miles per day) from the inlet to the outlet of Beddington Lake, Maine and suggested that 'the lake may slow migration'.

No shoals of smolts were seen just above Luichart dam in 1962, although a number of small shoals were seen farther up Loch Luichart up to the middle of June.

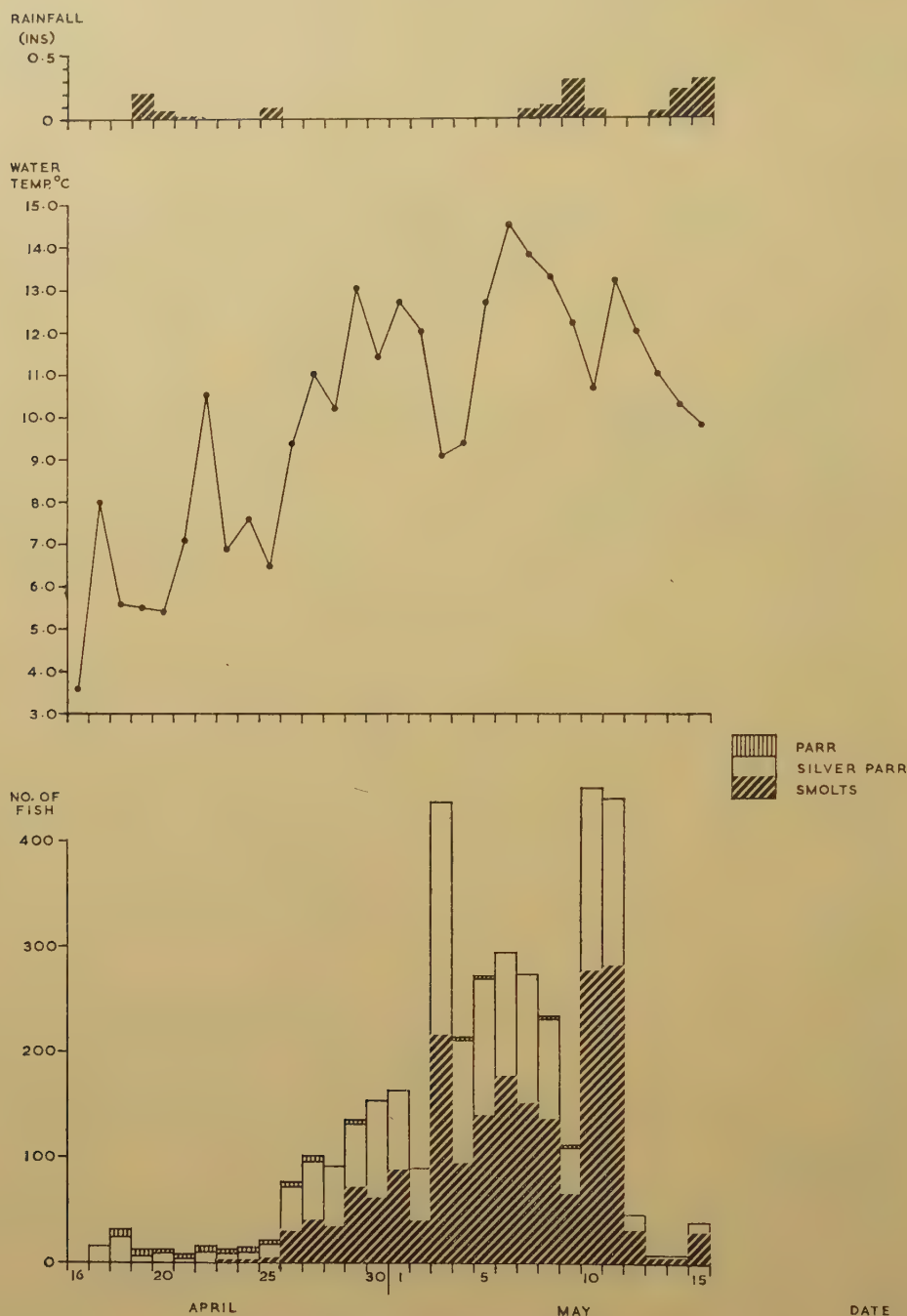


Fig. 11. Smolt migration, Caiseachan, 1962

(c) Growth

The calculated lengths of smolts for the River Bran and tributaries in the years 1960, 1961 and 1962 are given in Table 26.

The age composition of the smolts in 1961 and 1962 was very similar with the 2+ smolts comprising, on the average, 51.5%, 3+ smolts 47.8% and 4+ smolts 0.7% of the population. In 1960 the 2+ smolts comprised almost 64% and 3+ smolts 36% of the population. This increase in the number of 2+ year-old fish in 1960 may have been due to the good summer of 1959.

(d) Food

Over the period 1959 to 1961 95 smolt stomachs were examined. Those feeding in the streams, Allt a'Chomair and Allt dos Mhuicarain, were found to be eating similar food to the parr and fry. Those feeding in the lochs were generally taking more surface food including winged Ephemeroptera and Plecoptera, as well as Trichoptera and chironomid pupae.

(e) Smolt production

In 1961, 428 (or 11%) of the 3,851 smolts released after marking in the Bran were recaptured below Luichart dam. The total of marked and unmarked smolts caught at the three sites below Luichart dam was 2,072. Using the formula given by Bailey (1951, equation 2.15), the total smolt population is estimated as 18,609, with 95% confidence limits of 17,011 and 20,207.

This estimate represents a survival of about 2.4% of the unfed fry added in the relevant years and implies a smolt capacity of 3.5 smolts/100 sq. yd., which is slightly less than that of the Pollett River, after control of the mergansers (Elson, 1959). The records from Allt dos Mhuicarain, Allt a'Chomair and Allt Coire nan Laogh show that survival to the 1+ parr stage can be of the order of 2.6% (p. 21), so that losses between the 1+ year-old parr and the smolt stages would appear to be slight.

A similar calculation based on the records for 1962 gives an estimate of 17,416 smolts, with 95% confidence limits of 15,846 and 18,986, giving a survival of about 3.1% of the unfed fry added.

While some 18,000 smolts are produced in the Bran, once the smolts start their seaward migration serious losses occur and only a small fraction of this total (Table 27) reach Luichart trap below Luichart dam, which is still almost 13 miles from the sea. Some of these losses are due to predation by trout (pp. 31), pike (pp. 34) and birds (pp. 36). An estimate of the numbers of smolts taken by pike (Table 34) accounts for a tenth (1,880) of the smolt run in 1961 and probably a similar proportion in 1959 when it is estimated that 1,500 were taken. However, the number remaining after pike have taken their toll is still large. No estimate of the numbers taken by trout has been possible but predation by trout may well be severe.

When the smolts reach Luichart dam they can pass downstream either by way of the Borland fish lift or the chutes running down the face of the dam. In 1956, before this investigation started, there were no chutes and large shoals of smolts were seen to gather along the face of the dam. After the erection of chutes in 1957 fewer shoals of smolts were seen at the dam face and in 1961, when trapping was carried out below the Borland fish lift, it was found that more smolts passed through the dam via the chutes than by means of the Borland lift (p. 52).

The numbers of fish in Table 27 do not represent the numbers of Bran smolts passing through Luichart dam which are much higher (p. 52). Some of this heavy loss below the dam is due to predation by trout and gulls and some is probably due to the effects of handling. Predation is discussed in greater detail in the following section of the report, which describes the results of a study of the various predators and competitors of young salmon on the Bran system.

PREDATION AND COMPETITION

I. TROUT

The trout population was sampled at the same time as the population of young salmon using sweep nets and electric fishing apparatus. Trout were also taken in the fry traps on Allt a'Chomair and Allt dos Mhuicarain and in the box traps at Caiseachan. A number of larger trout, chiefly in Loch Luichart and in the River Conon immediately below Luichart dam, were caught by angling but fish were only caught by angling in areas where other methods could not be used because, as observed previously (Philips, 1929 and others), a fish when hooked frequently vomits part of its food.

(a) Population density

During the census of young salmon carried out by electrical fishing methods the number of trout caught was noted. Details of the population density are given in Table 28. The distribution shown in

this table is perhaps to be expected as many of the large trout in the main river spawn in the streams which therefore serve as nurseries for the young fish. Variations were found in the population densities of trout in these streams which were most probably related to the upstream and downstream movements of fish at different times of the year. Records from the traps at the mouths of Allt a'Chomair and Allt dos Mhuicarain show that most of the downstream movement of trout takes place in April and May and again in September and October.

The trout caught in the streams ranged from 3.0 to 19.0 cm. in length, but the majority taken were from 4.0 cm. to 14.0 cm. long. Large trout, up to 56.0 cm. long, were taken in the streams at spawning time and in the main river at all times of the year.

No comparable data are available on the population densities of trout in other areas. However, Le Cren (1958a) found in the north of England that the density of fry and underyearling trout in small becks from 30 cm. to 2 m. wide was of the order of 0.6 to 4.0 per square metre (50 to 334 per 100 square yards). In some of the smallest becks, only 50 cm. wide and 5 cm. deep, there were dense populations of fry, but older fish were scarce. In the larger becks he found the density of fry to be less than 0.5 per square metre (42 per 100 square yards), and fish more than a year old averaged very roughly over all the becks a density of one fish per metre length of beck. The few 'small rivers' he sampled which were of a size comparable to the Bran tributaries (6 to 10 m. wide), had very sparse populations of trout, perhaps because of their violent floods and unstable beds, reasons which might equally apply to some of the streams in Strathbran.

The ratio of salmon to trout occurring in the areas sampled electrically shows that in all cases except two, where the trout are slightly in the majority, the salmon outnumber the trout by at least two to one and in one instance by fifty to one. Even in those streams (Allt Coire nan Laogh, Allt a'Chomair and Allt dos Mhuicarain) where, up to 1959, no salmon fry had been planted, the salmon population, which had moved upstream from the main river, outnumbered the trout.

(b) *Competition with salmon*

The stomach contents of 165 trout fry and 514 trout were examined. These fish were taken from various sections of the main river and from a number of the tributaries. Salmon fry and parr were usually taken at the same time so that a comparison of feeding habits could be made.

The results of this comparison are given in Figs. 12 and 13, which show that, with a few exceptions, trout compete with salmon for the available food. Trout fry compete with salmon fry for all food organisms although the former tend to take more terrestrial organisms. There is competition between trout and salmon parr for the nymphs of Ephemeroptera and Plecoptera in the early part of the year but from September to December these nymphs are taken mainly by salmon. There is a marked competition for trichopteran and chironomid larvae and the percentage occurrence was similar in both trout and salmon. Trout, however, tend to eat more terrestrial food, especially during the spring and autumn and more trout seemed to be feeding on young salmon though the salmon parr were feeding on salmon fry.

Trout have been shown to compete with salmon for the available food by Frost (1950), Piggins (1962) and Thomas (1962). Frost thought it unlikely that interspecific competition was the primary cause of poor growth of brown trout in base deficient waters and therefore suggested that the growth of brown trout would not improve if the salmon were eliminated. This point is of particular interest in the case of the Bran as in this river the salmon outnumber the trout in many of the tributaries (p. 54) where they have moved upstream after being liberated in the main river as fry.

(c) *Predation on salmon*

(i) *Stream and river predation*

Salmon fry were found in trout in April, May, July, September and November. The largest numbers were found in trout in April and May shortly after the liberation of unfed fry into the stream. One trout, 9.0 cm. long, from Allt dos Mhuicarain was found to have eaten 11 salmon fry, while two, 14.0 and 15.0 cm. long, from Allt a'Chomair, had eaten 15 and 16 salmon fry respectively. This suggests that predation of salmon fry by small trout, as well as salmon parr and smolts, in the first few days after stocking, is likely to be high.

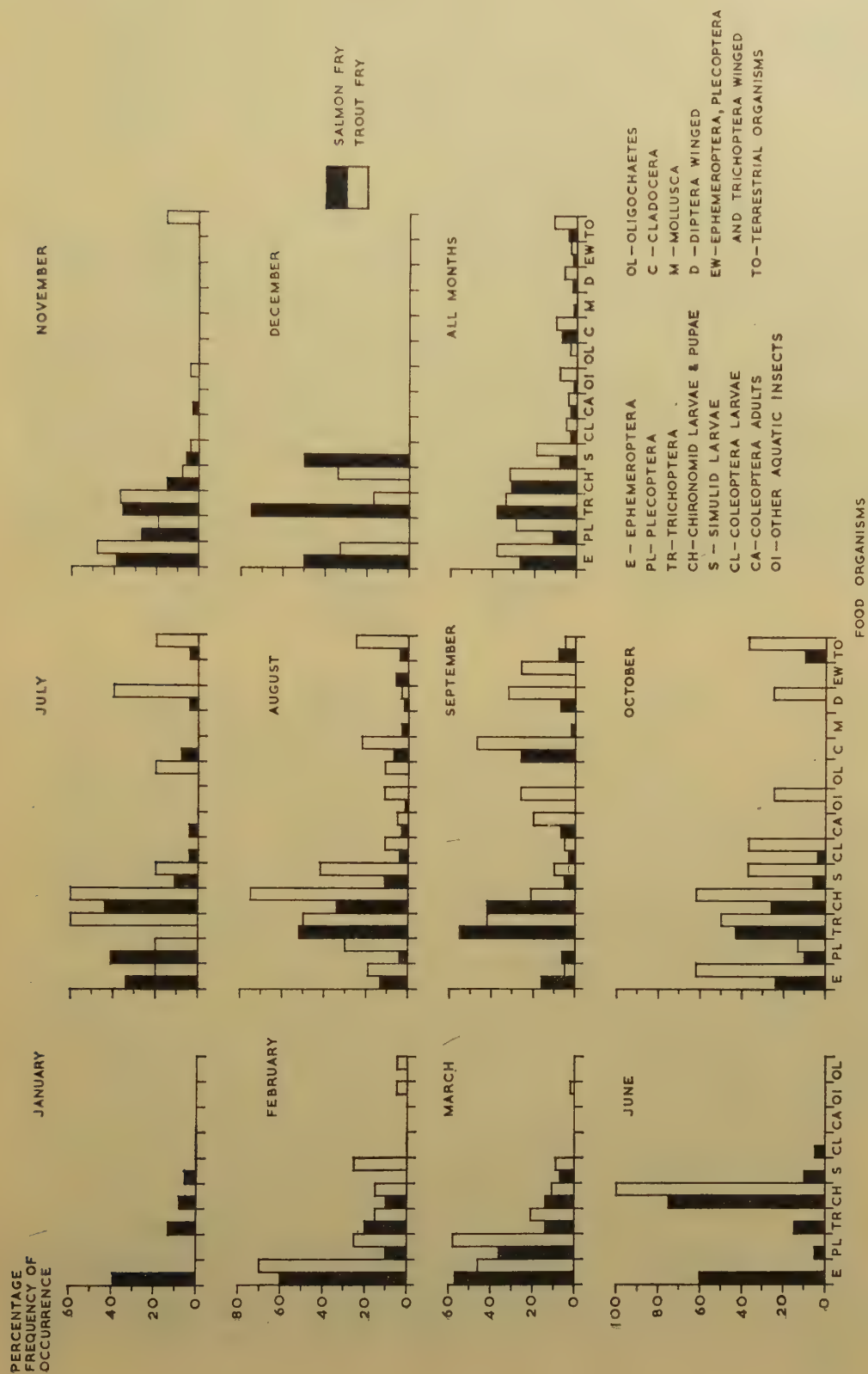


Fig. 12. Food taken by salmon and trout fry

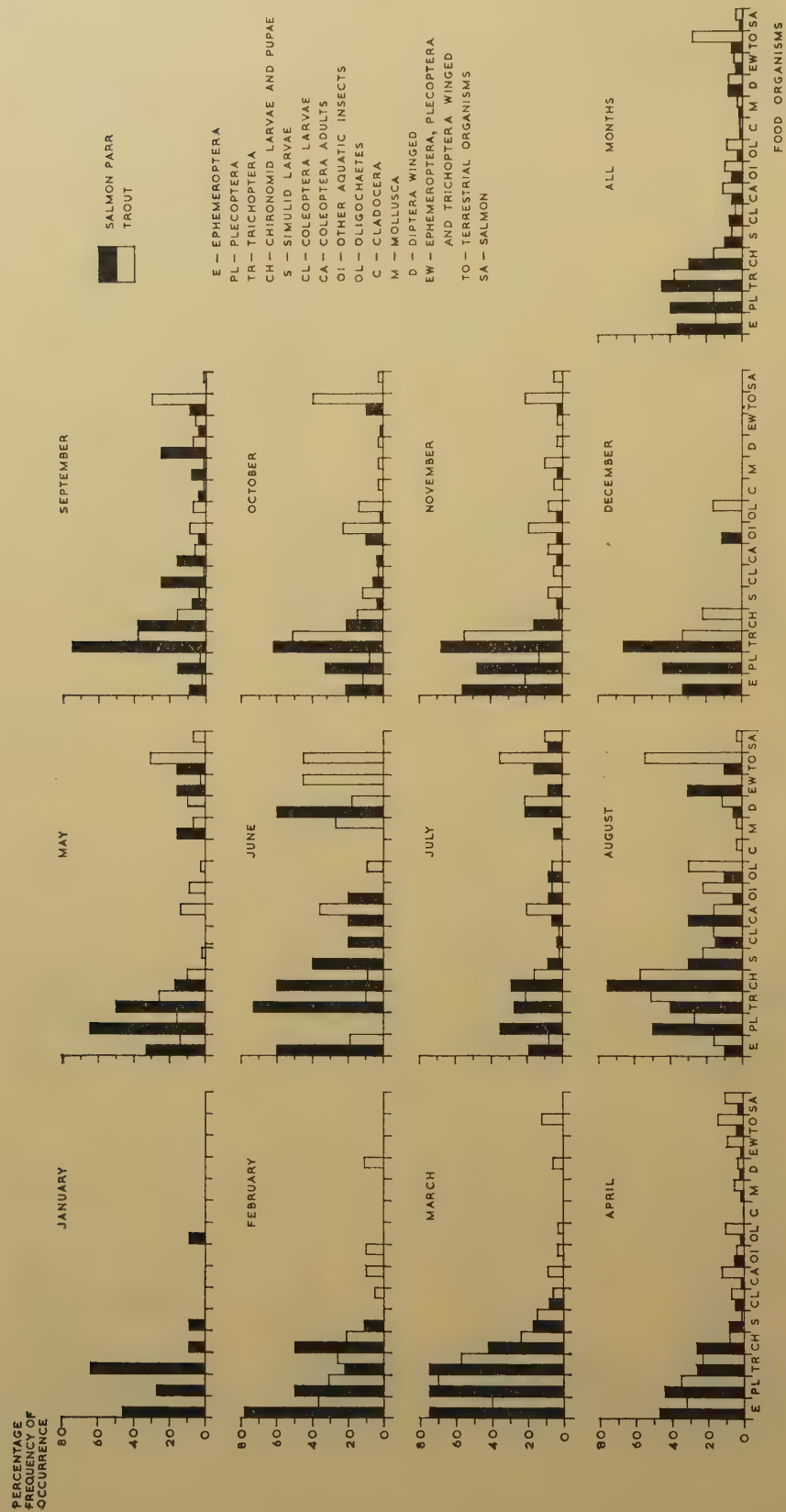


Fig. 13. Food taken by salmon parr and trout



Plate 1. Strathbran. Looking down the River Bran to Loch Achanalt and Loch a'Chuilinn



Plate 2. Smolt traps at Caiseachan



Plate 4. Smolt trap in Achanalt fish pass



Plate 3. Fry trap in Allt a'Chomair

Salmon parr were not found in trout stomachs very frequently. In May, July and August single specimens of trout from the Bran had taken salmon parr, and in October and November two trout in Allt dos Mhuicarain, one 17.5 cm. long and the other 27.8 cm. long, had eaten salmon parr.

Predation on smolts appeared to be heavy in the deep pools on the River Conon between Luichart dam and the smolt trap 400 yards downstream. During the last week of May and the first week of June, 1962, 18 trout ranging from 19.0 to 43.5 cm. in length were taken on rod and line. Five (27.7%) of these fish contained smolts and the two largest (41.0 and 43.5 cm. long) each contained eight salmon smolts.

It would therefore appear that stream and river predation is likely to be most serious in the spring at the time of smolt migration and the liberation of unfed fry. Stream and river predation can be divided into Ricker's (1952) type A and type B categories of predation.

(ii) *Predation in lochs*

While no systematic sampling of trout has been carried out on Loch Achanalt, Loch a'Chuilinn and Loch Luichart a number of trout were caught in the latter two lochs in the nets set for pike (p. 31). Three trout of up to 43.0 cm. in length were taken in Loch a'Chuilinn and a total of 12 smolt tags and nine smolts were found in their stomachs. At the upper end of Loch Luichart six trout containing a total of six tags were taken and at the lower end of the loch, immediately above Luichart dam, four trout containing five tags were caught. Larger samples of trout from Loch Luichart were caught on rod and line in 1961 and 1962. A total of 55 were caught between March and September, 1961. These fish had an average length of 32.5 cm. (18.0–61.5 cm.), the largest weighed 5 lb. and five were over 3 lb. in weight. In all, 13.0% of the fish contained smolts, but these were only present in fish caught between 26th April and 31st May and, during this period, 35.3% contained smolts. Between the middle of May and the end of June, 1962, 24 trout were caught, which had an average length of 27.7 cm. (19.5–62.0 cm.). None of the fish were found to have eaten smolts.

It has not been possible to make an assessment of the trout populations in any of these lochs so no estimate of the extent of predation on young salmon is possible. However, from the results obtained, it is considered likely that predation by trout on salmon smolts may be serious and this was even more likely to have been the case in 1956 and 1957 when generally larger, and probably more, trout occurred in these lochs. This is particularly true of Loch a'Chuilinn and Loch Luichart, especially the latter where, due to the flooding of the land after impoundment in 1954, the growth of trout was rapid. By 1959 the average weight of trout caught in Loch Luichart by anglers had decreased. However, a number of large trout, which appear to be the most serious predators, still occur in this loch.

2. PIKE

The North of Scotland Hydro-Electric Board employed a team of fishermen to fish for pike in the lochs on the Bran system to improve the chances of survival of the young salmon. Fishing was carried out from March to October each year from 1952-56 (inclusive) on Lochs Achanalt, a'Chuilinn and Luichart. No pike fishing was carried out in 1957 but in 1958 fishing was resumed by two netsmen employed by the Conon District Fishery Board. In 1958, netting started in March on Loch Luichart, in June on Loch a'Chuilinn and in July on Loch Achanalt and from 1959 to 1961 fishing was carried out on all three lochs from April to September (inclusive).

Most of the fishing was done by means of gill nets. The mesh used ranged from 5 in. (2½ in. knot to knot) to 1 in. The nets were usually 9 ft deep and varied from 20 yd to 120 yds in length; they were made either of fine cotton twine or nylon. They were set either at right angles to the shore from shallow into deep water or across the bays and were fished each day except Sunday. Perch traps, which usually caught pike ranging from 10 to 25 cm. long, were also used and set lines were used occasionally during the period 1952-56.

All the pike caught during the period 1958-61 were measured and the weight of each, excluding those partially eaten in the nets by gulls, was determined on the day of capture. Sex and maturity were also recorded. The larger stomach contents were identified on the day the fish were caught, the smaller organisms and the stomachs of pike under 20.0 cm. were preserved for later examination.

(a) *Numbers and weight*

The numbers and weight of pike caught in Lochs Luichart, a'Chuilinn and Achanalt over the period 1952-61 are shown in Table 29. As the fishing effort has not been constant each year and as the perch traps, which catch the smaller pike, were not used in Loch Achanalt, it is not possible to see from the annual catches whether there has been a decline in the pike population. However, a decrease in average weight since netting started is evident. Foerster and Ricker (1941) showed that by persistent gill netting in Cultus Lake, British Columbia, the predaceous fish which feed on young sockeye salmon were considerably, though unevenly, reduced. The effect of stopping fishing operations for even one year (there was no fishing in 1957) is shown very well in Table 29 where it can be seen that the average weights of the pike in Loch a'Chuilinn and Loch Achanalt in 1958 had trebled their 1956 value and the average weight of the pike in Loch Luichart had quadrupled the 1956 value.

(b) *Length frequency and distribution*

Pike ranging from 10.0 to 105.5 cm. in length were caught during the period 1958 to 1961 and further details of the length frequency distribution are shown in Fig. 14. In this figure it is possible to identify the earlier age groups particularly the 1+ and 2+ fish and the 1+ group can be traced through from April to August and identified in May of the following year in the 2+ group. In 1959 the 1+ group is particularly noticeable while in 1960 it is not so well-marked and in 1961 is poorly represented. This is also apparent in the 2+ group but the older age groups make it difficult to follow the fate of this particular age group. The older age or year groups are obscured by differences in growth rates of males and females and by the overlapping which occurs in the length distributions of adjacent age groups of the same sex. It is interesting to speculate on the reason for the decline in the 1+ age group and it is tempting to suggest that this is the effect of fishing on the pike stocks. While there is no doubt that the stocks have been reduced by fishing any accurate assessment of the effects of control on the pike population are complicated by variations in fishing effort and the possibility of recruitment from the pike stocks in Loch Gowan, Loch a'Chroisg and Loch Crann higher up the river system. The results of trapping at Caiseachan and Achanalt fish pass (pp. 51-52) show that a number of small pike move downstream.

(c) *Food*

A total of 3,000 pike stomachs was examined from Lochs Luichart (468), a'Chuilinn (1,428), Achanalt (1,007), Odhar (55) and the River Bran and its tributaries (42). The results are summarized in Tables 30 to 33.

Table 30 shows that the diet of small pike in Loch a'Chuilinn is almost entirely invertebrate and that fish occur in less than 10% of the stomachs examined. There is a marked seasonal difference in the diet; from April to June ephemeropteran nymphs and *Gammarus pulex* occur most often whereas from July to September trichopteran larvae and pupae and *Eurycercus lamellatus* predominate. This seasonal difference in the invertebrate diet is also apparent in pike from 20.0 to 39.9 cm. in Loch a'Chuilinn and Loch Achanalt (Tables 32 and 33). Invertebrates only occurred occasionally in the diet of pike over 40.0 cm. long in Lochs a'Chuilinn and Achanalt (Tables 31 and 32) and in all pike in Loch Luichart (Table 33). Frost (1954) and Healy (1956) have shown that the diet of small pike is chiefly invertebrate and changes to one of mainly fish when a length of more than 30.0 cm. is attained. Munro (1957) found that in Loch Choin, where forage fish were absent, even the larger pike chiefly fed on invertebrates.

The vertebrate food eaten by pike in these lochs is chiefly fish, though frogs are occasionally taken by the larger pike in April and May. The stomachs of pike from Lochs Achanalt and a'Chuilinn frequently contained salmon parr and smolts in April, May and, occasionally, June. Though young salmon occur in the stomachs of pike in Loch Luichart in the spring, perch generally occur more frequently in the diet of these fish during the spring and summer and perch also occur in the stomachs of pike from Lochs Achanalt and a'Chuilinn after the smolt migration is over. Other fish eaten include pike (particularly by the larger pike), brown trout and char. The proportion of fish with empty stomachs was much higher from June to September in Loch a'Chuilinn and Loch Achanalt, while in Loch Luichart the percentage feeding throughout the period April to September is much less than in the former two lochs. This is probably due to the larger average size of the pike in Loch Luichart and a greater percentage of fish in

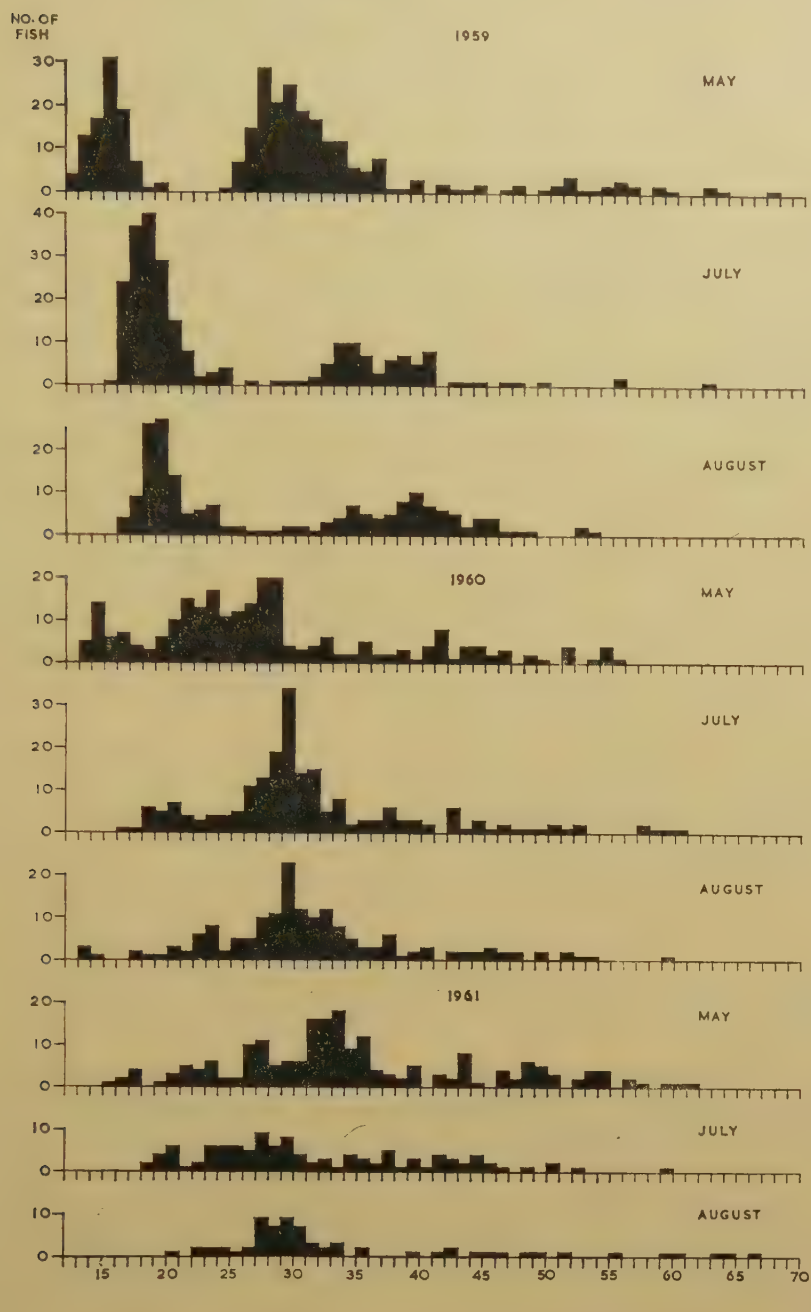


Fig. 14. Length frequency distribution of pike in Loch Achanalt, Loch a'Chuilinn and Loch Luichart

their diet. Frost (1954) showed a tendency for the percentage of feeding fish to decrease with increase in size of the pike and remarked that a high proportion of empty stomachs is a 'characteristic of fish-eating fish'.

The chief food of the 42 pike taken from the River Bran and its tributaries was young salmon, which occurred in nearly a third of the stomachs examined. Five of these 43 fish were taken from Allt a'Chomair and Allt dos Mhuicarain and all contained salmon parr and fry.

It would appear from these results that there is no selection of any particular species of fish and that the species of prey taken is chiefly determined by seasonal availability.

As was to be expected, no young salmon occurred in the stomachs of pike from Loch Odhar although at high water levels it is connected with the river. The main food of these fish was perch. Other food taken by pike in Loch Odhar included the young of the black-headed gull (*Larus ridibundus*) which nests at the side of this loch.

(d) *Relationship between pike and young salmon*

Pike have been shown to take salmon parr and smolts in April, May and June and salmon parr in October. The pike is therefore a type A predator according to the classification of predation given by Ricker (1952). This type of predation is likely to occur when a prey species is temporarily massed in unusual numbers and this occurs during smolt migration and, probably to a much lesser extent, during the downstream movement of parr in the autumn. Type A predation cannot last long and the pike in these lochs cannot make salmon their principal food throughout the year. However, if the type A situation persisted for long, due to the passage of smolts being delayed, it would end with the extermination of the prey. Pike caught in the River Bran were also found to be feeding on young salmon at other times of the year (July to September) and this behaviour places pike in the type B predation category as well.

Munro (1957) gives a figure of 4.8 lb./acre for the standing crop of pike in Loch Choin which is of the same order as the estimates of standing crops of pike given by Carlander (1955) for 59 game fish lakes (8.0 lb./acre) and 30 rough fish lakes (5.4 lb./acre) in Minnesota. Assuming a similar value to that of Loch Choin for Lochs Luichart, a'Chuilinn and Achanalt and knowing the average weight of the pike in each of these lochs it is possible to estimate the size of their pike populations. From this, using the evidence on the proportion of pike which contained parr or smolts it is possible to estimate the number of smolts taken each year during their downstream migration. These estimates are given in Table 34, which shows that the extent of smolt predation seems to fluctuate from year to year. No assessment has been possible for the River Bran. It should be noted, however, that removal of some of the pike might at first increase the rate of predation on young salmon because, as the size range of pike has been altered, more smaller prey species (such as young salmon) and fewer large prey species (such as trout, char and other pike) are eaten. Furthermore, large trout, previously taken by large pike, are no longer preyed on and are therefore available in greater numbers to prey on smolts.

3. PERCH

During the pike fishing operations an attempt was made to reduce the perch population as it was believed that the larger perch would eat the young salmon and the smaller perch compete with salmon parr for the available food supply.

Perch were caught in the gill nets set for pike and in traps. From 1952 to 1956 all the fish caught were weighed. In 1958 samples of the fish caught from Lochs Luichart, a'Chuilinn and Achanalt were weighed and measured, but no length measurements or weight determinations were made from 1959 to 1961 except for fish from which the stomach contents were examined. The examination of stomach contents from samples of perch over 16.0 cm. long was confined to recording the presence or absence of fish in the stomach contents.

(a) *Numbers and weight*

The numbers of perch caught during the periods 1952 to 1956 and 1958 to 1961 and the average weights from 1952 to 1956 are given in Table 35. There is a slight increase in the average weight of fish caught in Lochs Luichart, a'Chuilinn and Achanalt over the period 1952 to 1956. In 1958, after a year when there was no fishing, the average weight had dropped in Loch Luichart and Loch a'Chuilinn, but in Loch Achanalt the average weight had increased slightly but, as no perch traps were used in the latter loch, only the larger fish were being caught. Alm (1946) showed that reducing the size of perch populations in a series of Swedish tarns produced a steady increase in the average size of fish.

(b) *Food*

A total of 610 stomachs from perch over 16.0 cm. in length were examined from Lochs Luichart, a'Chuilinn and Achanalt. The stomach contents consisted almost entirely of *Gammarus pulex*, *Sialis lutaria* and ephemeropteran nymphs. No fish were present in any of the stomachs examined. Two perch fry

caught in the River Bran near Caiseachan had been eating *Eurycercus lamellatus* and chironomid and simuliid larvae.

(c) *Relationship between perch and young salmon*

The major part of the young salmon population of the Bran system occurs in the Bran itself while the perch occur in the lochs and the sluggish part of the river near Achanalt. Very few perch have been seen or caught in the faster reaches of the Bran and the few that have been caught at Caiseachan during the smolt migration may have dropped downstream from Loch Gowan and Loch a'Chroisg. It is therefore unlikely that there can be any serious competition between perch and young salmon and there is no evidence of predation. The removal of perch may disturb the food relations of fish to the detriment of the young salmon as perch are an important forage fish for pike and with a decline in the numbers of perch the pike would be compelled to eat other fish species to a greater extent. This condition was anticipated by Worthington (1949) who, after three seasons of intensive perch trapping in Windermere, decided to start pike netting. Furthermore, perch and trout, having a similar diet, compete with each other for the available food (Frost, 1946; Campbell, 1956) and Worthington (1949) has suggested that the decline in the trout and char populations in Windermere is due to the abundance of perch, and considers that the trout and char have increased after a number of years of intensive perch fishing. Le Cren (1958b) states that trout and char have almost certainly increased in abundance since the removal of perch and larger pike. Therefore, trout being predators of young salmon, an increase in the trout population due to the trapping of perch would be detrimental to young salmon stocks. Lastly, Alm (1946) and Le Cren (1958b) have demonstrated an increase in the average size of perch after netting operations and these large perch are more likely to take the young salmon.

4. CHAR

Char were caught in the pike nets, chiefly those set during the summer and autumn of 1958 and 1959 at the lower end of Loch Luichart. A total of 18 stomachs was examined and the results of this examination showed that planktonic Cladocera and chironomid larvae formed most of the diet. These findings agree closely with those of Frost (1946) for char from Windermere. As it is chiefly a plankton feeder, the char is likely to compete only with very small perch and it has been shown that reduction in perch stocks benefits the char (Worthington, 1949).

The char would not be detrimental to young salmon in any way as it is not a predator.

5. EELS

The eel is found in Loch Luichart and, to a lesser extent, in other lochs on the Bran system. It has not been seen in the Bran from Achnasheen to Caiseachan, or its tributaries, during trapping and electric fishing operations.

Elson (1957) describes eels feeding voraciously on newly planted underyearlings but Jones and Evans (1960, 1962) found that, in various Welsh rivers, predation by eels on salmonid eggs and young was negligible and they consider that eels are more important as competitors for the food of salmon and trout. Piggins (1962) also found that, on the Glenamong River in Ireland, eels were serious competitors of salmon and trout. However, as eels do not occur in the greater part of the Bran or its tributaries there will be little effect from this species on the young salmon population.

No information is available on the feeding habits of eels in Scottish lochs but Frost (1946) has shown that eels occurring in Windermere fed mainly on molluscs, larval aquatic insects, *Gammarus* spp. and *Asellus* spp. and concluded that 'the virtual absence of fish in the diet suggests that to the eel, primarily a benthic fish, all except fish like *Cottus gobio* would be out of its range and difficult to capture.'

An examination of 28 'silver' eels, with an average length of 55.6 cm. and a range of 33.5 to 81.3 cm., caught in Luichart trap, revealed that all stomachs were empty.

6. GOOSANDERS

A total of 18 birds were shot on the Bran system, and an examination of their stomachs showed that perch formed 62.5%, salmon 18.7%, trout 6.2%, pike 6.2% and fish remains 6.2% of their contents.

These results suggest that the goosander is not a serious predator of salmon on the Bran system, but the results may be misleading as 12 of the birds were shot during the winter and early spring as they flew from Loch Achanalt and Loch a'Chuilinn to their roosts in the evening. Two birds shot on the river in late April 1960, contained respectively 30 and 32 tags from salmon smolts. These tags had been attached to hatchery-reared smolts, of which 250 had been released, only three days previously, in the area in which the birds were shot. Evidence that they are serious predators of salmon is given by Mills (1962) who showed, from an examination of 147 goosanders from various Scottish waters, that salmon is by far the most important food item. Furthermore, the population density of the goosander on the River Bran is of the order of 2 to 3 birds per 10 miles of stream of 20 yards width (about 1 bird per 24 acres) which suggests that the goosander population is roughly at a level where, according to Elson (1962), control should have an effect on smolt production.

7. CORMORANTS

Cormorants (*Phalacrocorax carbo*) occur on the Bran system in nearly every month of the year but usually only single birds are recorded and the greatest number seen at any one time was six.

During the period 1959-62 cormorants were seen on 48 occasions particularly during March, April and May (34 sightings). Nearly all were seen on Lochs Luichart, a'Chuilinn and Achanalt and only on two occasions was a bird seen flying over the river. Ten cormorants were shot, the stomachs of four were empty and the occurrence of the various food organisms in the remaining six stomachs was: salmon (50%), perch (33%), trout (17%) and pike (17%). Because of the small numbers occurring on the Bran system, it is not thought that cormorants are serious salmon predators on this river system.

8. BLACK-HEADED GULLS

A colony of black-headed gulls (*Larus ridibundus*) nests at the head of Loch Achanalt each year and consequently these birds are to be found throughout Strathbran from the beginning of April until the middle of August. These birds are mainly to be seen along the course of the river and on the lochs. On numerous occasions they have been observed hovering above the river and dropping into the water and, in some instances, fish were later seen in their beaks. Permission was kindly granted by the Nature Conservancy to shoot a certain number of these birds during April, May and June each year and birds shot after being observed to drop into the water were found to have taken smolts. On other occasions these gulls were seen flying low and weaving over the water and occasionally dropping to pick objects from the water surface. Birds shot while exhibiting this behaviour were found to have been taking insects. This 'hawking' behaviour of black-headed gulls has been observed frequently, particularly in the evening, and is probably due to the presence of insects on or above the water. A total of 19 birds were shot on the Bran system. The stomachs of four were empty. The occurrence of the various food organisms in the remaining 15 stomachs was: plant material (60%), salmon (53%), and insects (20%). Other items present in the stomachs were three tags from salmon smolts. These results are probably biased as the birds in many cases were shot because they were on or close to the river. All the salmon present in the stomachs were smolts and in some cases these may have been moribund, especially those taken by gulls shot below Luichart dam as in all years except 1962 smolts were only released from the chute pools after being fin-clipped. As some of these fish were in a very 'tender' state before this operation the additional handling may have weakened them causing them to swim unsteadily near the surface. In other cases it is considered that smolts were taken as they swam close to the surface on bright days when they would be very conspicuous to birds flying overhead. Dunbar (quoted by Collinge, 1924, p. 352) states that these birds could not catch fish at a greater depth than five inches. Dresser (1871) gave as a regular food of this species small fish found in shallow water or near the surface. Ward (1914) mentioned that the examination of the crop contents of black-headed gulls collected in the neighbourhoods of the Solway Fishery, Dumfries and the Rothesay Fishery, Bute, showed that 64% contained the remains of trout. Berry (1933) considered them to be very serious predators of salmon fry on the River Ness.

No assessment of the extent of their predation on young salmon in the Bran has been possible but it is considered that it is not serious and is only likely to approach that state if low water and bright and sunny conditions prevail for a long time.

9. COMMON GULLS

The common gull (*Larus canus*) nests at the head of Loch Achanalt and around Loch Odhar and is common throughout Strathbran from early April until the middle of August. Its behaviour over water when fish were present and conspicuous was similar to that of the black-headed gull. A Nature Conservancy licence was granted to shoot a number of these birds during the period April to June each year and 16 birds were shot. The stomachs of three were empty; the occurrence of food organisms in the remaining 13 stomachs was salmon (46%), plant material (46%) and insects (31%). Other items present included one tag from a salmon smolt. The results are considered to be biased for the same reasons as those given for the black-headed gull. While no assessment of the extent of predation on young salmon by these birds has been possible it is considered that it is not serious.

10. GREATER BLACK-BACKED GULLS

The greater black-backed gull (*Larus marinus*) occurs in small numbers along the course of the river in the spring and five birds were shot near Loch a'Chuilinn in 1961. The stomach contents in every case were mammalian flesh, plant material and insects. However, Berry (1933) states that these birds take fish when on freshwater.

11. BLACK-THROATED DIVERS

Information on the food of black-throated divers, *Gavia arctica*, was obtained incidentally from two birds which were caught in the pike nets set in Loch a'Chuilinn and Loch Luichart. An examination of their stomach contents revealed that they had eaten trout. Berry (1936) considers that, owing to their preference for lochs rather than rivers, they are more likely to take trout than salmon.

Though predators exert an effect at all stages from the unfed fry to the smolt, it is perhaps useful to draw some distinction between the effect of predation during downstream migration and that at earlier stages in the life history. During the fry and parr stages, when the young salmon are mainly in the tributaries and the upper reaches of the main river, trout and goosanders seem to be the main predators. The effect of these predators cannot be assessed at all precisely but, because the proportion of unfed fry which survive to the late parr or smolt stages (3%) is not unusually low for a river system of this type, the effect of these predators may not be unusually severe.

During downstream movements the migrants encounter a series of predators, pike, goosanders, gulls and trout which play a part in the serious losses which have been shown to occur during passage downstream.

CONCLUSIONS AND SUMMARY

The River Bran is the largest of the headwaters of the Conon River system and has a catchment area of 73.6 square miles (191 km.²). For most of its length it lies between 400 and 500 feet (122 and 152 m.) above sea level. It is a moorland river and flows through an area composed mainly of pelitic gneiss, siliceous and granitic schists of the Moine series (pp. 5-6) much of which is drift and peat covered. The surrounding vegetation consists of deer grass and heather moor with *Molinia-Myrica* swamp and *Sphagnum* bog, interspersed with *Molinia* grassland and alluvial pasture (p. 7).

The mean monthly air temperature ranges from 54°F (12.2°C) in August to 30.5°F (-0.8°C) in January. The average annual rainfall is 77.4 in. (1966 mm.).

The upper part of the Bran is a fast flowing stretch consisting of pools and riffles with a bed of gravel and stones and much of this can be classified under Carpenter's minnowreach, while the tributary streams come into the category of trout beck. The lower part of the Bran is typical coarse fish reach and is meandering and sluggish and flows into a shallow, reedy piece of water, Loch Achanalt, which is in process of silting up. Below Loch Achanalt there are two more lochs, Loch a'Chuilinn and Loch Luichart.

The mean annual flow of the river is 355 cusecs. Details of the incidence and volume of floods are given in Fig. 4. The mean monthly water temperature ranges from 1.4°C in January to 14.5°C in July

(Table 2). Chemical analyses of the water in various parts of the Bran system reveal that it is an extremely poor and base-deficient stream with a pH value varying from 5.4 to 6.2 and an alkalinity from 0.6–4.6 p.p.m. CaCO_3 (Table 3).

A study of the bottom fauna (pp. 11–14) reveals that the average number of organisms per square foot in the main stream is 80.2 (863 m^2), while on the tributary streams it ranged from 27.6 (247 m^2) (Allt a'Chomair) to 104.0 (1119 m^2) (Allt Coire nan Laogh). Ephemeroptera and Chironomidae were the most important constituents of the bottom fauna, with maximum numbers of Ephemeroptera occurring from November to March (Fig. 5). The quantitative composition of the bottom fauna of the Bran was similar in all the sections except one (Table 4), where more turbulent conditions prevailed, but qualitative differences occurred in the bottom fauna of the various sections. It is suggested that, in streams of this type, the drift fauna and organisms of terrestrial origin make a significant contribution to the food supply.

An assessment was made of the population density of young salmon by electrical fishing methods (pp. 15–16) and it was estimated that the average number of 1+ and 2+ parr was about 7.3/100 sq. yd., which is similar to that found for two other tributaries of the Conon, the Meig (7.6) and the Blackwater (8.6) and also similar to that found by Elson (1962) for the Pollett River (7.8 to 9.8). A value of 7.3 parr/100 sq. yd. indicates that the total parr population throughout the area studied, excluding Loch Achanalt, Loch a'Chuilinn and Loch Luichart, is about 37,000.

The average length of the fry at the end of their first year is 5.0 cm. and the growth rate of the parr is similar to those in the River Forss, Caithness, and in some of the tributaries of the Thurso River.

Results of the examination of the stomach contents of fry and parr (Tables 11 and 12) show that the former fed principally on the nymphs of Ephemeroptera and Plecoptera during the winter, Cladocera during the late summer, trichopteran larvae during the autumn and chironomid larvae throughout the year. The food of the parr was similar to that of the fry though they also fed on salmon fry, particularly in the spring just after the latter had been liberated in the stream.

A detailed study was made of the movements and survival of fry in three tributary streams, Allt a'Chomair, Allt dos Mhuicarain, and Allt Coire nan Laogh and it was found (pp. 17–21) that, (a) there was a downstream movement of fry which took place within the first five weeks after planting (Tables 14, 15) and that the numbers of fry moving downstream each day increases with a rise in water level and a consequent increase in flow (Table 16), (b) the mortalities in the stream are high (Table 19) and (c) in the streams the survival to the underyearling stage ranges from 0.2% to 2.6% of the unfed fry added. It is considered that the heavy mortalities were due to the high rate of stocking and to predation by trout, salmon parr and salmon smolts.

The smolt migration was sampled in 1960, 1961 and 1962 (pp. 21–27). The migration was found to start after the water temperature was consistently above 10°C. Downstream movement took place at an average rate of approximately 0.5 miles (0.8 km.) per day in 1961 and 0.7 miles (1.12 km.) per day in 1962. The age composition of the smolt run varied slightly during the period of this investigation. In 1960, about 64% of the migrants were two-years old and 36% three-years old (Table 26) but in 1961 and 1962 the corresponding proportions were 52% and 48%. Favourable weather conditions during the summer of 1959 may have been the reason for the higher proportion of two-year-old smolts in 1960.

The estimated smolt production from the Bran was 18,600 in 1961 and 17,400 in 1962. A comparison of these estimates with the numbers of unfed fry stocked in earlier years indicates that survival from unfed fry to the smolt stage was 2.4% in 1961 and 3.1% in 1962.

It would appear that smolt production from the Bran system is comparable with that of the Pollett River, New Brunswick (Elson, 1962) which has an area similar to that of the Bran. In spite of competition and predation in the fry and parr stages by trout and predation by birds, some 18,000 smolts are produced. Once these smolts start their seaward migration, however, severe losses occur and only a small fraction of this total reaches Luichart trap below Luichart dam, which is still almost 13 miles from the sea. Some of these losses are due to predation by trout, pike and birds. An estimate of the numbers taken by pike (Table 34) accounts for a tenth (1,880) of the smolt run in 1961 and probably a similar proportion in 1959 when it was estimated 1,500 were taken. No estimate of the numbers taken by trout has been possible but predation by trout may well be severe.

The presence of small shoals of smolts at the dam face each year, except 1962, after the main smolt run would suggest that either the dam had had a delaying effect or the fish had lost their migratory urge. The dam probably has some delaying effect but the fact that a proportion of the fish had passed downstream would suggest that those fish remaining in the impoundment had lost the urge to migrate due to changes in their physiology. Nothing is known of the fate of these fish but, as relatively few enter Luichart trap after the end of June and few appear in the trap the following year, they are thought to die either from natural causes or predation.

This investigation has shown that a satisfactory number of smolts can be produced in a river such as the Bran from plantings of about 700,000 unfed fry. There is evidence which suggests that this rate of planting is too high, e.g. 18,600 smolts were produced in 1961 from plantings of some 750,000 unfed fry but in the following year, 550,000 unfed fry produced some 17,400 smolts. Tests of still lower planting rates should be made and production could probably be improved further by reducing the competitors and predators within the nursery areas.

However, even if the measures just mentioned proved successful, there is still the problem of predation during downstream migration. Present evidence suggests that persistent netting only serves to keep the pike population in check and this probably also applies to the trout population. Further, the artificial barriers *en route* (Achanalt barrage, Luichart dam) may delay downstream migration and so contribute, in several ways, to the losses which occur. A practical solution to this problem would be to transport young fish migrating out of the Bran to a point downstream below Torr Achilty, the lowermost dam. Though the transportation of smolts has its dangers and losses might well occur, the present rate of loss is so high that it is difficult to see how transportation could be other than advantageous. For example, even if some 40–50% of the smolts died during transportation (and this, on evidence from Scotland and from Sweden, may be more than ten times the loss which actually occurs) the number surviving to be replaced in the river would be about ten times that now surviving as far as Luichart trap.

It is therefore suggested that the contribution of the Bran to the smolt stock of the Conon River system might be increased by:

- a) Trapping the downstream migrants before they enter the series of lochs in the lower reaches of the Bran and transporting them to a point below Torr Achilty.
- b) Assessing the effects of reducing the planting rate of unfed fry.
- c) Reducing and controlling the competitors and predators on the nursery grounds.

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APPENDIX

The invertebrate fauna of the River Bran and its tributaries.

ANNELIDA

Chaetopoda

Oligochaeta

Eisenella spp.

Nais spp.

Lumbriculus variegatus, Müll.

Hirudinea

Rhynchobdellida

Glossisiphonia complanata, L.

Herpobdellida

Helobdella stagnalis L.

ARTHROPODA

Crustacea

Branchiopoda

Diplostraca

Cladocera

Eurycerus lamellatus, Müll

Alonopsis elongata, Sars

Alona affinis, Leydig

INSECTA

Pterygota

Exopterygota

Plecoptera

Taeniopteryx nebulosa (L.) Aubert

Brachyptera putata, (Newm.)

B. risi, (Mort.)

Protonemura meyeri, (Pict.)

Amphinemura sulcicollis, (Steph.)

Nemoura avicularis, Mort.

Leuctra inermis, Kemp.

L. hippopus, (Kemp.)

L. fusca, (L.)

Capnia vidua, Klap.

Perlodes microcephala, (Pict.)

Isoperla grammica, (Poda)

Dinocras cephalotes, (Curt.)

Perla bipunctata, Pict.

Chloroperla torrentium, (Pict.)

Odonata

Cordulegaster boltoni, Donovan

Ephemeroptera

Leptophlebia marginata, (L.)

L. vespertina, (L.)

Ephemerella ignita, (Poda)

Caenis rivulorum, Etn.

Baetis rhodani, (Pict.)

B. pumilus, (Burm.)

B. niger, (L.)

B. scambus, Etn.

Siphonurus linnaeanus, (Etn.)

Rithrogena semicolorata, (Curt.)

Heptagenia sulphurea, (Müll.)

H. lateralis, (Curt.)

Ecdyonurus venosus, (Fabr.)

E. torrentis, Kim.

Endopterygota

Megaloptera

Sialis fuliginosa, Pict.

Trichoptera

Limnophilus spp.

Anabolia nervosa, Curt.

Stenophylax spp.

Sericostoma personatum, Spence

Lepidostoma hirtum, F.

Leptocerus spp.

Hydropsyche angustipennis, Curt.

H. instabilis, Curt.

Polycentropus flavomaculatus, Pict.

Rhyacophila dorsalis, Curt.

Hydroptila spp.

Oxyethira spp.

Coleoptera

Latelmis volkmari, Panz.

Helmis maugei, Bed.

Limnius tuberculatus Müll.

Platambus maculatus, L.

Diptera

Simulium spp.

Tipula spp.

Hemerodromia spp.

Tanytarsus spp.

Pentaneura spp.

Corynoneura spp.

Orthochironominae spp.

Haematopota pluvialis, L.

Chrysops spp.

Eristalis spp.

Mollusca

Gasteropoda

Pulmonata

Limnaea pereger, (Müll.)

Ancylastrum fluviatile, (Müll.)

Lamellibranchiata

Eulamellibranchiata

Sphaerium corneum, L.

TABLE 1

The Area and Gradient of the River Bran and its tributaries

	Area (sq. yd.)	Gradient
River Bran ^a	471,190 (393,962)	1 in 292
Abhuinn a'Chomair	21,182 (17,710)	1 in 105
Allt Acadh na Sindhe	2,515 (2,103)	1 in 7
Allt Coire nan Laogh	3,626 (3,032)	1 in 8
Allt a'Chomair	8,558 (7,155)	1 in 23
Allt dos Mhuicairain	1,268 (1,066)	1 in 13

Figures in brackets denote m².

^a Including Amhain Loch a'Chroisg, but excluding Loch Achanalt, Loch a'Chuilinn and Loch Luichart.

TABLE 2

Mean Monthly Temperature of the River Bran

Month	Temperature (°C)	Month	Temperature (°C)
January	1.4	July	14.5
February	3.0	August	13.5
March	4.6	September	11.9
April	7.5	October	8.4
May	12.3	November	4.8
June	14.2	December	2.2

TABLE 3

Composition of the Waters of Strathbran

Water	Conductivity (mhos/cm. at 20)	pH	Alkalinity (p.p.m. CaCO ₃)	Na ⁺ (p.p.m.)	K ⁺ (p.p.m.)	Ca ⁺⁺ (p.p.m.)	Mg ⁺⁺ (p.p.m.)	Cl ⁻ (p.p.m.)	SO ₄ ⁻⁻ (p.p.m.)
Loch a'Chroisg	37	6.30	1.4	6.6	0.5	2.4	0.8	12.3	5.4
Loch Gowan	36	6.50	2.0	4.2	0.5	1.6	0.6	7.4	3.7
Abhuinn a'Chomair	—	6.16	1.4	5.9	0.4	2.2	0.8	11.0	4.9
River Bran (section 8)	—	6.21	1.4	9.0	0.6	2.6	1.3	17.6	5.8
Allt Acadh na Sindhe	—	5.44	0.6	5.0	0.4	1.8	0.6	8.7	5.4
Allt Coire nan Laogh	29	6.30	1.6	3.8	0.3	1.0	0.5	6.3	2.5
Allt a'Chomair ^a	—	6.25	2.4	8.7	0.5	3.1	1.2	16.8	5.9
Loch na Moine Beag	29	5.50	0.4	3.8	0.3	1.1	0.5	6.9	3.3
Allt dos Mhuicairain	33	5.80	0.6	4.3	0.3	1.1	0.5	7.9	2.9
River Bran (section 5)	—	6.25	1.6	8.3	0.5	3.2	1.0	16.6	5.6
River Bran (section 3)	—	6.18	1.8	8.3	0.5	3.2	1.1	16.8	4.9
Loch Achanalt	—	6.08	1.4	8.3	0.5	2.8	1.0	16.0	5.8
Loch a'Chuilinn	—	6.35	2.4	8.8	0.5	3.4	1.2	19.5	3.4
Loch Luichart	—	6.09	1.6	7.4	0.5	3.1	1.0	14.3	6.6

^a Mean of five readings.

TABLE 4

Bottom Fauna of the River Bran

Group	Section 8	Section 7	Mean No./sq. ft. Section 6	Section 5	Section 4
Oligochaeta	2.0	0.3	0.2	0.5	0.8
Rhyncobdellida	—	—	—	—	0.09
Herpobdellida	0.05	—	—	—	0.09
Cladocera	1.3	0.5	—	1.0	11.0
Plecoptera	5.6	6.9	3.2	8.0	5.7
Odonata	—	—	—	—	0.07
Ephemeroptera	18.9	40.7	9.0	7.5	18.4
Megaloptera	—	0.02	—	—	—
Trichoptera	14.6	6.0	4.6	17.3	6.4
Coleoptera	0.4	1.1	1.4	1.2	7.5
Diptera					
(a) Chironomidae	21.8	14.7	5.5	21.7	8.0
(b) Other Diptera	2.0	2.5	1.0	1.2	2.0
Hydracarina	1.8	2.0	0.9	2.3	1.1
Pulmonata	9.7	1.0	—	0.3	3.0
Lamellibranchiata	1.0	—	—	—	—
Total	79.1(851)	75.4(812)	26.0(280)	61.2(659)	64.0(689)

Figures in brackets denote number/m².

TABLE 5

Assessments of the Bottom Fauna

River	Alkalinity (p.p.m. CaCO ₃)	Organisms (No./m ²)	Authority
SCOTLAND			
Bran		863	Mills
Allt Coire nan Laogh	1.6	1,119	Mills
Allt a'Chomair	0.8-4.6 ^a	297	Mills
Allt dos Mhuicarain	0.6	849	Mills
Meig		899 ^b	Mills
Thurso:			
Sleach Water	22.9	4,066	
Halkirk Burn	126.0	3,016	
Sinclair Burn	7.6	730	Allen, 1941
Eigeach	4.8	490 ^c	Morgan, personal communication
Duibhe	6.2	129 ^c	Morgan, personal communication
ENGLAND			
Eden	166.0	4,633	Allen, 1941
Ford Wood Beck	—	6,580	Macan, 1958
Tees	—	408	Butcher, Longwell and Pentelow, 1937
Towy	—	1,580	Jones, 1951
WALES			
Ystwyth	—	916	Jones, 1958
Ceriw	8.9	708	Badcock, 1949
Merddwr	—	592	Badcock, 1949
IRELAND			
Glenamong	9.6	751	Griffith and Norton, 1961

^a—Range of several readings. ^b—Mean of two samples. ^c—Mean of four samples.
—No information.

TABLE 6
 Numbers of Fry and Parr released in the Bran Watershed

Year	Numbers		Year	Numbers	
	Unfed Fry	Parr		Unfed Fry	Parr
1953	206,000	0	1958	715,000	0
1954	120,000	8,000 ^a	1959	773,000 ^c	0
1955	750,000	4,000 ^b	1960	420,000	0
1956	1,410,000	0	1961	84,570	0
1957	750,000	0			

^aReleased in October. ^bUnderyearlings planted in July. ^c75,000 planted as eyed ova.

 TABLE 7
 Population Densities of Salmon Fry and Parr in the River Bran and its Tributaries

Area	Date		Area (sq. yd.)	No. of Fry and parr	Index ^a	Mean Index	Parr Index ^a
River Bran, section 8 (Site 1)	Dec.	1958	253	13	5.3	4.7 (0.05)	4.7 (0.05)
	Nov.	1958	511	21	4.1		
Abhuinn a'Chomair (Site 1)	Aug.	1958	1,008	58	5.8	14.6 (0.17)	7.4 (0.08)
	Nov.	1958	543	127	23.4		
Allt Coire nan Laogh (Site 1) ^b	Aug.	1958	628	36	5.7	7.5 (0.08) ^c	7.5 (0.08)
	Nov.	1958	702	50	7.1		
	Feb.	1959	473	47	9.4		
	Mar.	1959	398	32	8.0		
River Bran, section 7 (Site 1)	Aug.	1958	765	127	16.5	12.6 (0.15)	4.5 (0.05)
	Nov.	1958	556	66	11.8		
	Jan.	1959	266	49	18.4		
	Nov.	1958	465	18	3.9		
Allt a'Chomair ^b	Nov.	1958	1,120	56	5.0	7.6 (0.08) ^c	7.6 (0.08)
	Mar.	1960	763	56	7.3		
	Mar.	1960	636	67	10.5		
Allt dos Mhuicairain ^b	Aug.	1958	325	66	20.3	14.7 (0.18) ^c	14.7 (0.18)
	Nov.	1958	411	32	7.8		
	Feb.	1959	213	34	16.0		

^a Number of fish per 100 sq. yd. (m²). ^b Area not stocked with fry. ^c Before fry planting.

 TABLE 8
 Characteristics of Salmon Fry in the River Bran and its Tributaries

Month	No. of fish	Length (cm.) ^b	Mean Weight (g.)	Condition Factor ^a
May	200	2.7 (±0.008)	—	—
June	0	—	—	—
July	38	3.4 (±0.067)	0.45	119
August	146	4.2 (±0.100)	0.90	122
September	34	4.7 (±0.124)	—	—
October	17	4.2 (±0.112)	0.76	104
November	236	4.9 (±0.050)	1.21	102
December	27	5.0 (±0.069)	—	—
January	44	4.7 (±0.138)	1.08	101
February	4	5.6 (±0.266)	—	—
March	50	5.3 (±0.075)	1.69	113

^a The condition factor is calculated from the formula

$$K = \frac{W + 10^4}{L^3} \text{ where } W \text{ is the weight in g. and } L \text{ is the length in cm.}$$

^b Figures in brackets indicate standard error.

TABLE 9

Lengths of Fry in Allt dos Mhuicarain and Allt a'Chomair

Month	Average Length (cm.)			
	Allt dos Mhuicarain		Allt a'Chomair	
	1960	1961	1960	1961
January	—	5.1 ± 0.103 (9)	—	4.9 ± 0.147 (5)
February	—	5.1 ± 0.152 (5)	—	4.9 ± 0.120 (16)
March	—	5.1 ± 0.126 (10)	—	5.1 ± 0.101 (19)
April	2.7 ± 0.016 (50)	—	2.6 ± 0.017 (50)	—
May	2.7 ± 0.036 (20)	—	2.6 ± 0.013 (108)	—
June	3.2 ± 0.086 (10)	—	3.0 ± 0.052 (20)	—
July	3.7 ± 0.092 (10)	—	3.5 ± 0.123 (10)	—
August	4.7 ± 0.228 (10)	—	4.5 ± 0.053 (124)	—
September	4.8 ± 0.026 (206)	—	4.8 ± 0.019 (767)	—
October	4.8 ± 0.092 (12)	—	4.7 ± 0.166 (10)	—
November	5.1 ± 0.108 (9)	—	4.7 ± 0.087 (35)	—
December	—	—	4.9 ± 0.152 (8)	—

Figures in brackets indicate the number of fish measured.

TABLE 10

Calculated lengths of Parr, River Bran and Tributaries

Area	Age (yrs)	No. of fish	Average calculated length (cm.) at the end of winters		
			1	2	3
Abhuinn a'Chomair	1+	70	4.7	—	—
	2+	28	3.8	7.4	—
River Bran, Section 8	1+	10	3.7	—	—
	2+	4	3.3	7.8	—
	3+	1	4.0	8.5	12.0
Allt Coire nan Laogh	1+	51	4.6	—	—
	2+	27	3.4	7.0	—
River Bran, section 7	1+	22	4.3	—	—
	2+	6	3.3	7.3	—
Allt a'Chomair	1+	150	4.5	—	—
	2+	41	3.5	7.4	—
	3+	1	3.0	6.5	9.0
Allt dos Mhuicarain	1+	127	4.5	—	—
	2+	59	3.5	7.4	—
	3+	5	3.6	7.4	10.6
River Bran, section 5	1+	14	4.8	—	—
	2+	12	3.4	7.5	—
All areas	1+	444	4.4	—	—
	2+	177	3.5	7.4	—
	3+	7	3.5	7.5	10.5

TABLE II
 Food of Salmon Fry, River Bran and Tributaries

Month	January		February		March		June		July		August		September		October		November		December	
	No.	F	No.	F	No.	F	No.	F	No.	F	No.	F	No.	F	No.	F	No.	F	No.	F
No. of fish	38		10		14		20		27		117		62		30		33		2	
Mean length (cm.)	4.6		4.9		5.1		3.2		3.4		4.3		4.6		4.2		4.8		5.1	
Percentage composition	No.	F	No.	F	No.	F	No.	F	No.	F	No.	F	No.	F	No.	F	No.	F	No.	F
Oligochaeta	—	—	—	—	—	—	—	—	—	—	0.2	0.8	—	—	1.3	3.3	—	—	—	—
Cladocera	—	—	—	—	—	—	—	—	11.1	23.0	16.2	6.8	48.4	25.3	—	—	—	—	—	—
Leptophlebia spp. n.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Epiplatia ignita n.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Baetis spp. n.	47.3	29.0	31.5	20.0	20.5	28.5	33.3	45.0	15.0	33.3	0.8	2.5	—	—	1.3	3.3	—	—	—	—
Rithrogena semicolorata n.	2.6	2.6	10.5	10.0	12.8	7.0	—	—	—	—	2.0	5.9	1.7	11.3	24.3	13.3	28.3	27.2	—	—
Hemiptera spp. n.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ecdyonurus spp. n.	10.5	10.5	26.3	30.0	12.8	21.4	—	—	0.8	3.7	0.2	0.8	0.8	6.4	4.0	6.6	9.0	18.1	8.3	50.0
Taeniopteryx nebulosa n.	—	—	—	—	2.5	7.0	—	—	—	—	—	—	—	—	—	—	1.5	3.0	—	—
Protonemura meyeri n.	—	—	—	—	2.5	7.0	—	—	—	—	—	—	—	—	—	—	3.0	6.0	—	—
Amphimerura sulciollis n.	—	—	—	—	2.5	7.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Leuctra inermis n.	—	—	5.3	10.0	5.3	14.3	—	—	—	—	—	—	0.1	1.6	—	—	—	—	—	—
L. hippopus n.	—	—	—	—	2.5	7.0	—	—	—	—	0.4	0.8	—	—	—	—	—	—	—	—
L. fusca n.	—	—	—	—	2.5	7.0	—	—	—	—	0.4	1.7	—	—	—	—	—	—	—	—
Isonychia grammatica n.	—	—	—	—	12.8	14.3	1.3	5.0	12.3	4.7	0.6	2.5	0.2	3.2	—	—	9.0	18.1	—	—
Chloropoda torrentium n.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4.5	9.0	—	—
Plecoptera n. indet.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Stenophylax spp. l.	7.9	8.0	5.3	10.0	5.1	14.3	4.1	15.0	—	—	—	—	—	—	1.3	3.3	—	—	8.3	50.0
Hydropsyche spp. l.	10.5	5.3	5.3	10.0	—	—	—	—	2.6	7.4	16.1	22.8	10.7	9.6	6.7	10.0	16.6	24.2	8.3	50.0
Oxyethira spp. l.	—	—	—	—	—	—	—	—	2.6	3.7	18.8	36.7	8.6	32.2	16.2	23.3	7.5	12.1	—	—
Trichoptera l.	—	—	—	—	—	—	—	—	—	—	2.4	7.4	—	—	2.6	6.6	4.5	9.0	33.3	100.0
Trichoptera p.	—	—	—	—	—	—	—	—	—	—	0.6	1.7	1.0	6.4	—	—	1.5	3.0	—	—
Coloptera l.	—	—	—	—	—	—	1.3	5.0	0.8	3.7	1.6	4.2	0.2	3.2	1.3	3.3	—	—	—	—
Coloptera adult aqnat.	—	—	—	—	—	—	—	—	0.8	3.7	0.8	3.4	1.1	8.0	—	—	—	—	—	—
Chironomidae l. and p.	13.1	8.0	10.5	10.0	5.1	14.3	51.3	70.0	35.4	44.4	26.7	32.5	20.4	41.9	28.3	26.6	9.0	15.1	—	—
Simulium spp. l.	5.2	5.3	—	—	7.6	7.0	2.7	—	5.3	11.1	4.9	11.1	0.4	4.8	2.6	6.6	3.0	6.0	41.6	50.0
Tipulidae l.	—	—	—	—	—	—	—	—	—	—	0.2	0.8	—	—	—	—	—	—	—	—
Ancylastrum fluviatile	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Limnaea peregr	—	—	—	—	—	—	—	—	—	—	0.2	0.8	—	—	—	—	—	—	—	—
Surface Food	—	—	—	—	—	—	—	—	—	—	0.4	2.5	0.4	1.6	—	—	—	—	—	—
Ephem., Plec. and Trich. winged	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Diptera a.	—	—	—	—	—	—	—	—	0.8	3.7	2.5	5.9	—	—	—	—	—	—	—	—
Terrestrial organisms	—	—	—	—	—	—	—	—	—	—	1.0	3.4	1.0	8.0	2.6	10.0	—	—	—	—
Total organisms	37	1.0	19	2.0	39	2.7	72	3.6	113	4.1	489	4.1	679	10.9	74	2.4	66	2.0	12	6.0
Mean no. of organisms/stomach	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

No. Number of food organisms, expressed as a percentage of the total organisms eaten.
 F Percentage frequency of occurrence in total fish examined.
 n. nymph. l. larva. p. pupa. a. adult.

TABLE 13

Numbers of Fry released in Tributaries of the River Bran

Tributary	Year	
	1960	1961
Allt dos Mhuicarain	16,150 (27/4)	16,800 (21/4)
Allt a'Chomair	52,200 (21/4, 27/4, 4/5)	50,850 (21/4)
Allt Coire nan Laogh	15,000 (27/4)	16,900 (21/4)

Figures in brackets indicate date of release.

TABLE 14

Numbers of Young Salmon caught in the Allt dos Mhuicarain trap

Year	Month	No. of Salmon			No. of Days Trap Out of Operation
		Fry	Parr	Smolts ^a	
1959	November	24	13(5)	0	2
	December	4	6	0	15
1960	January	0	4	0	11
	February	0	1	0	18
	March	5	11	3	5
	April	388	31	11	0
	May	2,479	9	8	9
	June	29	6	1	8
	July	13	2	0	8
	August	3	5	0	7
	September	7	10(1)	0	1
	October	8	23(4)	0	0
	November	9	14(5)	0	0
	December	0	2	0	4
1961	January	9	5	0	3
	February	4	1	0	13
	March	9	5	0	6
	April	498	39	6	1
	May	2,186	7	2	1
	June	69	0	0	2
	July	5	1	0	6
	August	2	7	0	1
	September	5	1	0	3
	October	0	24(16)	0	2
	November	0	13(11)	0	0
	December	0	0	0	23
1962	January	0	1	0	29
	February	4	1	0	19
	March	0	0	0	4
	April	0	10	5	2

Figures in brackets denote number of ripe male parr.

^aIncluding silver parr.

TABLE 15

Numbers of Young Salmon caught in the Allt a'Chomair trap

Year	Month	No. of Salmon			No. of Days Trap Out of Operation
		Fry	Parr	Smolts ^a	
1960	March	12	14	10	0
	April	395	19	79	2
	May	12,155	3	41	7
	June	66	1	1	11
	July	51	0	0	5
	August	138	1	0	2
	September	59	10	0	0
	October	9	29(27)	0	0
	November	38	22(21)	0	0
	December	3	4(4)	0	9
1961	January	4	4	0	10
	February	16	3	0	14
	March	19	3	0	9
	April	160	40	31	1
	May	7,237	3	22	2
	June	78	1	0	3
	July	345	1	0	10
	August	73	3	0	2
	September	24	0	0	5
	October	28	1	0	8
	November	9	9(9)	0	5
	December	0	7(5)	0	21
1962	January	0	0	0	31
	February	2	3	0	21
	March	1	3	0	4
	April	0	3	15	2

Figures in brackets denote number of ripe male parr.

^aIncluding silver parr.

TABLE 16

Numbers of Fry entering the traps in Allt dos Mhuicarain and Allt a'Chomair, compared with rainfall for the previous 24 hours

Date	Rainfall (in.)	No. of Fry entering		Date	Rainfall (in.)	No. of Fry entering	
		Allt dos Mhuicarain	Allt a'Chomair			Allt dos Mhuicarain	Allt a'Chomair
1960				1961			
Apr. 28	0	54	17	Apr. 22	0.03	54	169
29	0	151	215	23	0.05	45	25
30	0.06	183	122	24	0.03	346	16
May 1	0	182	122	25	0	3	0
2	0	167	117	26	0.08	8	9
3	0.14	7	153	27	0.05	0	3
4	0.15	517	469	28	0	16	4
5	0	518	991	29	0.06	26	13
6	0	82	1,316	30	0.04	0	131
7	0.03	28	995	May 1	0.03	34	1
8	0	52	1,041	2	0.04	16	67
9	0	154	1,141	3	0.08	35	48
10	0	76	425	4	0.29	30	120
11	0.31	0	208	5	0	813	2,263
12	0	127	1,102	6	0.32	20	0
13	0	36	573	7	0.84	3	0
14	0	0	336	8	0.98	^a	^a
15	0.02	0	358	9	0.04	7	^a
16	0.12	0	320	10	0	408	1,115
17	0	0	1,390	11	0	184	1,391
18	0	0	255	12	0	262	362
19	0	0	81	13	0	108	668
20	0	0	73	14	0	139	320
21	0	0	34	15	0	71	343
22	0.08	0	29	16	0	22	68
23	0.79	0	43	17	0	22	86
24	0.04	505	456	18	0	12	158
25	0.09	17	54	19	0	1	28

^a Traps flooded.

TABLE 17

Numbers Migrating Downstream after Successive Plantings, Allt a'Chomair, 1960

	Date(s)	No. Planted	No. taken in Trap
April	21	21,720	—
	22-27		41 (0.2)
	27	17,640	
	28-May 4		1,215 (3.1)
May	4	12,835	
	4-12		7,219 (14.2)

The figures in brackets indicate the percentage of fry present which passed through the trap during the period indicated.

TABLE 18

Disposition of Fry after Planting in Allt dos Mhuicarain,

Allt a'Chomair and Allt Coire nan Laogh, 1960 and 1961

	1960 planting		1961 planting		
	Allt dos Mhuicarain	Allt a'Chomair	Allt dos Mhuicarain	Allt a'Chomair	Allt Coire nan Laogh
No. planted	16,150	52,200	16,800	50,850	16,915
No. through trap	2,919 (18.0%)	12,864 (24.6%)	2,765 (16.4%)	7,917 (15.5%)	—
No. in stream	206 (1.3%)	724 (1.4%)	46 (0.2%)	462 (0.9%)	224 (1.3%)
Percentage mortality in stream	98.4	98.1	99.6	99.6	—
Density ^a of fry at planting	1,274 (15.24)	1,062 (12.70)	1,324 (15.84)	1,034 (12.37)	467 (5.5)
Density ^a of fry at census	16.2 (0.2)	14.7 (0.18)	3.6 (0.043)	9.4 (0.11)	6.2 (0.07)
Density ^a of parr at census	18.2 (0.22)	4.7 (0.05)	11.9 (0.14)	5.7 (0.07)	14.7 (0.18)
Total density ^a at census	34.4 (0.41)	19.4 (0.23)	15.5 (0.19)	15.1 (0.18)	20.9 (0.25)

^a No. of fish/100 sq. yd. (m²).

TABLE 19

Number of Fish entering the Traps at Caiseachan, 1960

Month	Salmon		Trout	Pike	Perch
	Parr	Smolts			
March ^a	5 ^b	0	0	0	0
April ^c	2 ^b	98	3	0	0
May	0	725	23	3	1
Total	7	823	26	3	1

^a From 23rd March. ^b All silvered. ^c From 1st to 13th and 21st to 30th April.

TABLE 20

Number of Fish entering the Traps in Achanalt Fish Pass, 1960

Month	Salmon		Pike	Perch
	Parr	Smolts		
March	0	0	0	0
April	0	24	1	1
May	0	157	5	0
Total	0	181	6	1

TABLE 21

Number of Fish entering the Trap in Achanalt Fish Pass, 1961

Month	Salmon—Silver Parr and Smolts		Trout	Pike
	No. unmarked	No. previously marked		
April	343	12 ^a	1	2
May	679	121 ^b	2	2
June	4	0	0	0
Total	1,026 ^c	133 ^c	3	4

^a 3 from Allt a'Chomair, 8 from Caiseachan, 1 from Allt Coire nan Laogh.^b 1 from Allt a'Chomair, 120 from Caiseachan. ^c About 76% were smolts.

TABLE 22

Number of Fish entering the Traps at the Exit from the Borland Fish Lift, Luichart Dam, 1961

Period	No. of Silver Parr and Smolts		Total
	Unmarked	Previously marked	
Mar. 22-31	2	0	2
April	18	0	18
May	237	70	307
June	116	27	143
July	1	1	2
Aug. 1-7	0	0	0
Total	374	98(20.7)	472 ^a

^a Approximately 99% of the fish were smolts.

Figures in brackets denote percentage of total recapture.

TABLE 23

Number of Fish entering the Chute Pools below Luichart Dam, 1961

Month	No. of Silver Parr and Smolts		Total
	Unmarked	Previously marked	
May	928	269	1,197
June	182	41	223
Total	1,110	310(21.8)	1,420

No smolts were taken in the chute pools in July and August.

Figures in brackets denote percentage of total recapture.

TABLE 24

Speed of Smolt Migration on the River Bran, 1961

	Distance (Miles)	No. of Fish Recaptured	Time (Days)		Av. Speed ^a
			Av.	Range	
Caiseachan to:					
Loch Achanalt	3 $\frac{1}{4}$	8	5	3-12	0.65 (1.04)
Loch a'Chuilinn	4 $\frac{1}{4}$	6	7 $\frac{1}{2}$	3-16	0.56 (0.90)
Achanalt Fish Pass	5 $\frac{1}{2}$	14	13	4-18	0.42 (0.67)
Below Luichart Dam	12 $\frac{3}{4}$	5	23	12-46	0.55 (0.88)
Achanalt Fish Pass to:					
Below Luichart Dam	7 $\frac{1}{4}$	12	23	12-40	0.29 (0.46)

^a Miles per day (kilometres per day).

TABLE 25
Speed of Smolt Migration on the River Bren, 1962

	Distance (Miles)	No. of fish Recaptured	Time (Days)		Av. Speed ^a
			Av.	Range	
Allt a'Chomair to:					
Caiseachan	2 $\frac{1}{4}$	30	2	$\frac{7}{8}$ —8	1.12 (1.80)
Achanalt Fish Pass	7 $\frac{3}{4}$	1	12	—	0.65 (1.04)
Luichart trap ^b	15 $\frac{1}{4}$	3	12	9—13	1.27 (2.04)
Allt dos Mhuicairin to:					
Caiseachan	1 $\frac{3}{4}$	2	2	$\frac{7}{8}$ —3	0.87 (1.39)
Caiseachan to:					
Achanalt Fish Pass	5 $\frac{1}{2}$	26	10	4—22	0.55 (0.88)
Luichart trap ^b	13	38	21	7—59	0.61 (0.98)
Achanalt Fish Pass to:					
Luichart trap ^b	7 $\frac{1}{4}$	4	11 $\frac{1}{4}$	9—13	0.66 (1.06)
Achanalt Intake Weir to:					
Luichart trap ^b	7 $\frac{1}{2}$	1	14	—	0.54 (0.86)

^a Miles per day (kilometres per day).

^b All recaptured at Luichart as no trapping was carried out at the chutes or below the Borland fish pass.

TABLE 26
Calculated Lengths of Smolts, River Bran and Tributaries, 1960-62

Year	Age (years)	No. of Fish	Percentage of total	Av. length at Capture (cm.)	Av. calcd length (cm.) at end of each winter			
					1	2	3	4
1960	2+	280	63.8	12.2	4.9	10.3	—	—
	3+	159	36.2	12.6	3.5	7.4	11.4	—
1961	2+	163	51.2	11.9	4.6	10.5	—	—
	3+	153	48.1	12.1	3.7	7.8	11.6	—
	4+	2	0.7	13.2	3.2	6.5	9.5	12.2
1962	2+	73	52.2	11.4	4.9	10.6	—	—
	3+	66	47.1	12.1	3.4	7.5	11.9	—
	4+	1	0.7	17.7	3.7	9.0	13.5	18.0

TABLE 27
Number of Bran Smolts entering Luichart Trap, 1957-62

Year	No. of fish
1957	350
1958	1,000
1959	750
1960	950
1961	450
1962	1,120

TABLE 28
Population Densities of Trout in the River Bran and its Tributaries

Area	Date	Area (sq. yd.)	No. of Trout	Index ^a	Mean Index ^a
River Bran, section 8 (Site 1)	Dec. 1958	253	6	2.3	1.70 (0.020)
	(Site 2) Nov. 1958	511	6	1.1	
Abhuinn a'Chomair (Site 1)	Aug. 1958	1,008	1	0.1	0.025 (0.003)
	(Site 2) Nov. 1958	543	2	0.4	
Allt Coire nan Laogh (Site 1)	Aug. 1958	628	39	6.2	6.9 (0.07)
	Nov. 1958	702	24	3.4	
	Feb. 1959	473	24	5.1	
	July 1959	285	28	9.8	
	(Site 2) Mar. 1959	398	40	10.0	
River Bran, section 7 (Site 1)	Aug. 1958	765	1	0.1	0.15 (0.002)
	Nov. 1958	556	2	0.3	
	Jan. 1959	266	0	0.0	
	(Site 2) Nov. 1958	465	1	0.2	
Allt a'Chomair	Nov. 1958	1,120	11	0.9	1.60 (0.020)
	Mar. 1960	763	16	2.1	
	Mar. 1960	636	15	2.3	
	Sept. 1960	4,915	88	1.8	
	Sept. 1961	4,915	41	0.8	
Allt dos Mhuicarain	Aug. 1958	325	30	9.2	3.30 (0.039)
	Nov. 1958	411	7	1.7	
	Feb. 1959	213	7	3.3	
	Nov. 1959	400	4	1.0	
	Sept. 1960	1,268	42	3.3	
	Sept. 1961	1,268	16	1.3	

^a Number of fish per 100 sq. yd. (m²).

TABLE 29

Annual Catches of Pike from Lochs Luichart, a'Chuilinn and Achanalt, 1952-61

Year	No. of Fish	Average Weight (lb.)	Heaviest Fish (lb.)
Loch Luichart			
1952	260	6.8	20
1953	186	3.3	16½
1954	135	1.2	5
1955	303	1.1	7
1956	810	0.9	32
1957	—	—	—
1958	413	3.6	10
1959	139	2.5	9
1960	184	1.5	11¼
1961	111	2.1	5½
Loch a'Chuilinn			
1952	801	0.8	12½
1953	1318	0.5	4
1954	550	0.3	3
1955	323	0.2	3½
1956	377	0.5	5
1957	—	—	—
1958	218	1.5	6
1959	830	0.2	10¼
1960	435	0.2	2
1961	207	0.4	4
Loch Achanalt			
1952	243	4.3	17½
1953	760	1.5	16½
1954	924	0.6	8
1955	419	0.3	3
1956	637	0.5	10
1957	—	—	—
1958	190	1.6	16
1959	422	0.6	8½
1960	456	0.6	21½
1961	366	0.5	6¾

—Indicates no fishing.

TABLE 34

Estimates of Numbers of Smolts taken by Pike in
Lochs Luichart, a'Chuilinn and Achanalt, 1959-61

Loch	Year	Est. Size of Pike Population	Percentage of Pike examined containing Smolts ^b	Est. No. Smolts Taken ^a
Achanalt	1959	1,400	16.0	314 (± 64)
	1960	1,500	37.5	743 (± 165)
	1961	1,750	16.5	391 (± 78)
a'Chuilinn	1959	3,250	14.3	617 (± 108)
	1960	2,850	30.0	985 (± 140)
	1961	1,700	35.2	772 (± 156)
Luichart	1959	3,300	11.3	623 (± 206)
	1960	5,500	9.3	639 (± 295)
	1961	3,850	15.2	720 (± 225)

^aFigures in brackets indicate standard error.

^bDuring smolt season.

TABLE 35

Number of Perch caught during the periods 1952-56 and 1958-61

Year	Loch Luichart	Loch a'Chuilinn	Loch Achanalt
1952	18,718 (0.2)	2,442 (0.3)	169 (0.5)
1953	3,094 (0.3)	4,476 (0.3)	635 (1.1)
1954	799 (0.4)	933 (0.4)	1,756 (0.5)
1955	1,265 (0.5)	471 (0.4)	997 (0.5)
1956	2,224 (0.5)	1,734 (0.5)	1,187 (0.7)
1958	15,480 (0.1)	1,502 (0.3)	453 (0.8)
1959	30,593	1,567	1,567
1960	9,156	2,548	1,974
1961	10,125	1,749	1,937
	91,454	17,422	10,675

Figures in brackets indicate the average weight of fish in lb.

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